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Geomedicine

Geography and Personal Health

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Introduction

Linking one's own personal health status to specific geographic factors provides a powerful set of information that medical professionals can use to improve the quality of the care they deliver. In this e-book, I set forth the notion that the emerging field of [geomedicine](#) will produce a new type of medical intelligence that will leverage national spatial data infrastructures to benefit personal human health.

What Is Geomedicine?

At the present time, very little health-relevant geographic information is available to a clinician at the time of a medical diagnostic encounter, and it is certainly not a typical part of a comprehensive medical record. Geomedicine uses modern information technology to deliver information on a patient's potential environmental exposures into the hands of the clinician while they are in the examination room.

With geomedicine, we will experience an increase in the number of patients who benefit from a more precise clinical understanding of the links between their health and where they live, work, and play.

What Is GIS?

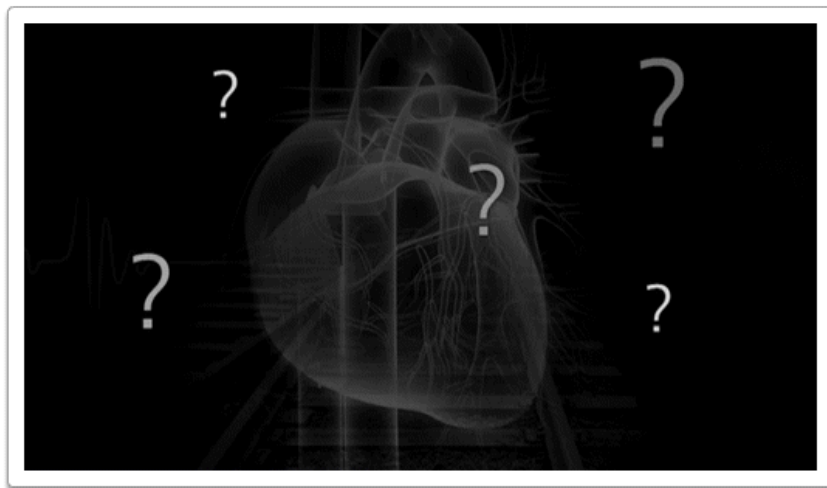
[Geographic information system \(GIS\)](#) technology integrates hardware, software, and data for capturing, managing, analyzing, and displaying all forms of geographically referenced information. GIS allows us to view, understand, question, interpret, and visualize data in many ways that reveal relationships, patterns, and trends in the form of maps, globes, reports, and charts. GIS helps us answer questions and solve problems by looking at data in a way that is quickly understood and easily shared.

GIS has long been used to monitor the health of the planet. With geomedicine, GIS is now being used to monitor the health of individuals. It makes sense, because the health of people depends on the health of the planet—and that's the basic idea behind geomedicine.

The Missing Link

Geography and Personal Health

In 2001, I was hit by a train. Not a real train—but it might as well have been! My train was a heart attack. When it happened, I thought, *Why me? Why now? Why here?* I thought I was in good health. I had followed the advice of many doctors, but still the train had hit me. As I worked through my crisis, I started thinking about the many factors that could have contributed to my heart attack and wondered why I had not had better warning.



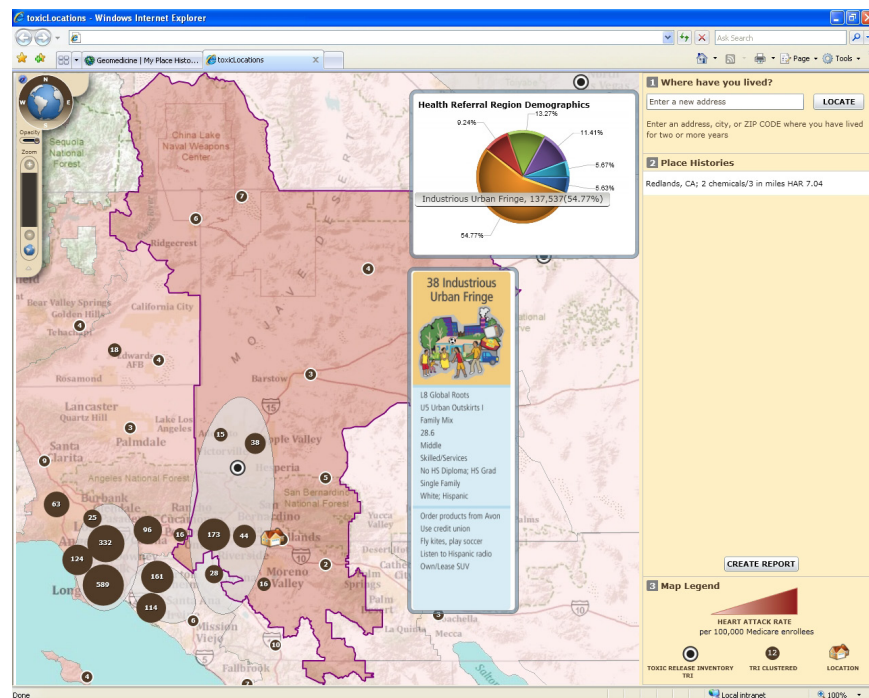
Watch my presentation [Your Health Depends on Where You Live](#) from TEDMED 2009.

Having worked in and around health care for many years, I had learned a great deal about how to avoid a heart attack—you know, the usual things: avoid risks, live a healthy lifestyle, control my weight, choose better food and drink, don't smoke, reduce stress . . . all excellent advice to a reasonable person.

Like many of you, I had provided a lot of personal information to my health care providers over many years, such as family, medication, surgical, disease, allergy, and social history as well as my lifestyle inventory. I now wondered why none of that information had actually helped prevent the roaring train bearing down on me.

I soon began to discover that there were many different reasons why I may have been hit by that train. In addition to all the usual suspects—high blood pressure, high cholesterol, stress, genetics—I discovered that many environmental conditions and exposures could greatly increase my risk of a heart attack, things like air quality and exposures to pollutants—some that I did not even know existed in the communities where I lived. As I began to research the places where I had lived both as a child and an adult, I began to discover disturbing information on what I—and my doctors—could have already known about the quality of my

various environments and what the impact may have been on my health.



Heart attack rates, the Environmental Protection Agency (EPA) Toxics Release Inventory, and other information can show links between your health and where you have lived.

(Copyright Esri and the Trustees of Dartmouth College)

My search was not easy, even with use of the Internet. Large volumes of health information were spread across many

governmental and health-related websites of varying quality. While I cannot prove that any specific environment caused my heart attack, there was plenty of evidence that some of the contaminants I had been exposed to in places where I had lived were well-known precursors to circulatory and respiratory disease—and, yes, heart attacks. It was at this moment that I realized that a physician looking at my health history, in the absence of any specific information about my unique environmental exposures, would be less likely to warn me, let alone guide me away from the oncoming train wreck. The problem, as I have come to see it, is that none of my physicians had a useful or easy way of translating all that rich environmental health research into something that would directly benefit me. Why was it so difficult for me and my doctors to connect the dots?

Every place I have ever lived is part of my medical history.

The impact of breathing bad air in many of the places I have lived will surely follow me wherever I go; therefore, my medical record should be automatically informed about new research findings of relevant health risks.

Unfortunately, today my medical record—and probably yours as well—is already a vast collection of clinical facts, observations, test results, and diagnostic conclusions but remains silent about the accumulation of environmental health impacts and risks. As both a patient and a good-health-seeking consumer, I need to be better served by the great wealth of environmental health

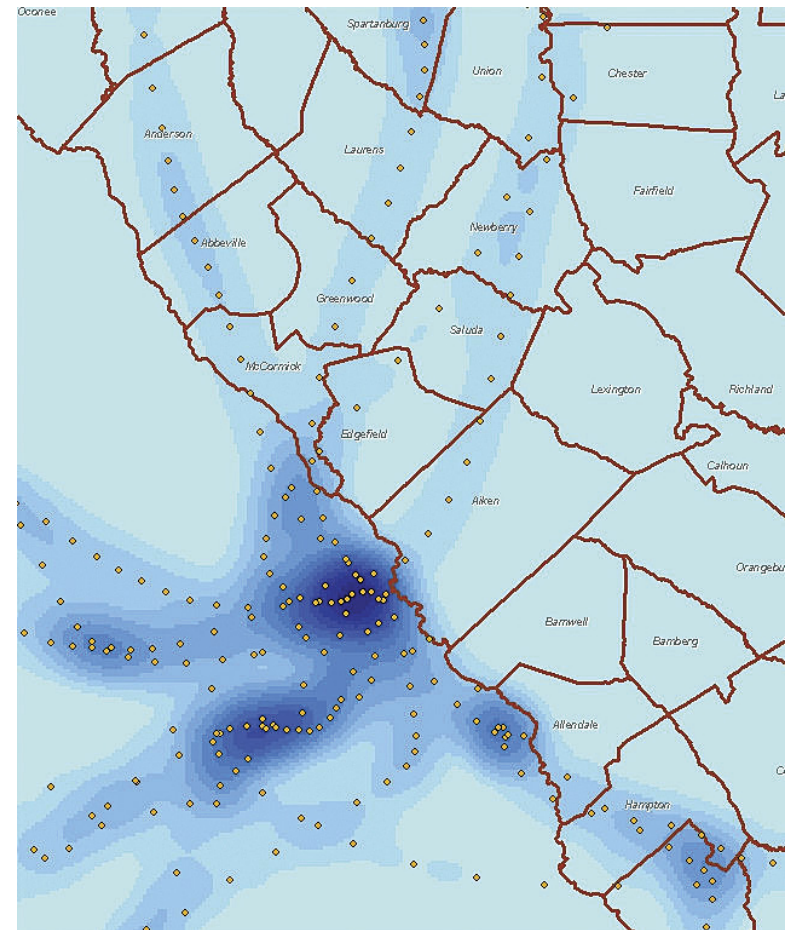
research that is available. I also need to do what I can to increase the ability of physicians to consume and use this information in smarter ways.

I invite you to think about the places you've lived or where you live today, and learn more about the impacts of your environments on your own health. Think about how you might approach your own health discovery process. There is much to learn about geomedicine and how it can become a valuable tool in clinical practice. I hope this discussion of geomedicine is the beginning of your personal journey to discover ways to stay healthy longer.

Improving Personal Health and Safety

There is abundant evidence that the use of geographic information has had a dramatic impact on the work of health professionals. Medical epidemiologists, the front line of disease detectives, have used GIS extensively in their fight against diseases that have a clear relationship between person, place, and time. GIS has also played an important role in protecting communities from otherwise overlooked risks and toxic exposures.

Geomedicine applies the power of GIS technology to personal health. As this concept continues to be adopted by more health care professionals, physicians will increasingly use geomedicine to help diagnose, treat, and prevent illness and, in some cases,



A trajectory density map of the Aiken area in the state of South Carolina shows high ozone days.

even make recommendations to patients on where they might live, work, and play.

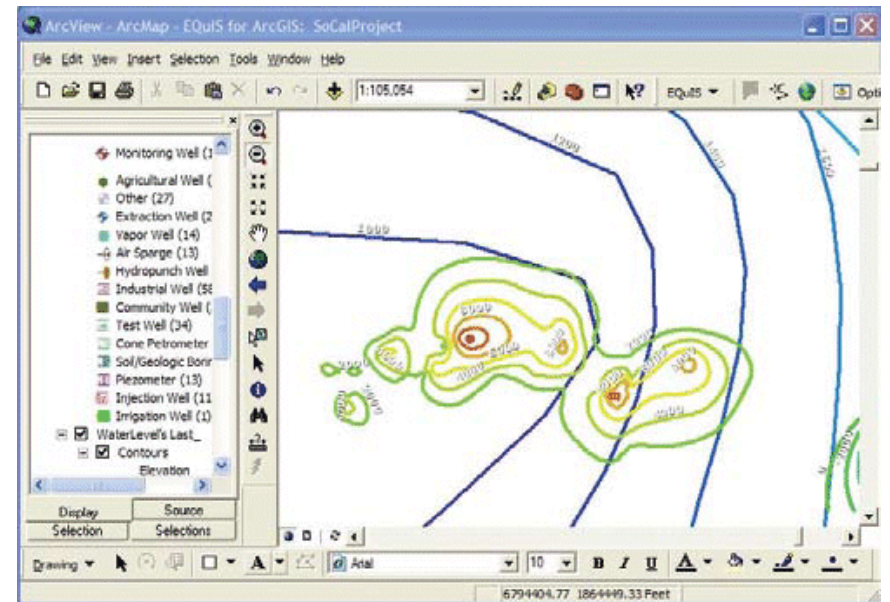
Health care accreditation and oversight bodies have also expressed interest in redefining the geographic scope of patient safety, encouraging health care providers to consider the value of integrating internally generated health care information with externally available population health information. Principal drivers for such a redefinition of quality care and patient safety include the impacts of unintentional toxic exposures, compromised environmental conditions, unexpected situational dangers, untoward outcomes, medical misadventures (during or after clinical care), and the lack of timely logistical information for distributing health professionals and dispensing medical supplies.

The persistent and unmistakable convergence of two powerful forces—personal human health factors and environmental conditions—continues to drive geomedicine forward. Using GIS to deliver geomedical intelligence to health care practitioners could profoundly alter the way providers view patient safety and quality of care.

A Road Map to Better Health

What do Hippocrates and Dr. Ethan Berke have in common? For starters, each chose to be a physician. Despite 2,400 years' difference in their ages—Hippocrates, of course, lived in about 400 BC and Berke lives in the present—they both understood the direct connection between the places in people's lives and their respective impact on personal health. Hippocrates and Berke both concluded that your health depends on the air you breathe,

the water you drink, and the environment in which you live. In fact, Berke believes that geography matters in personal health, and so do many of his colleagues in family medicine.



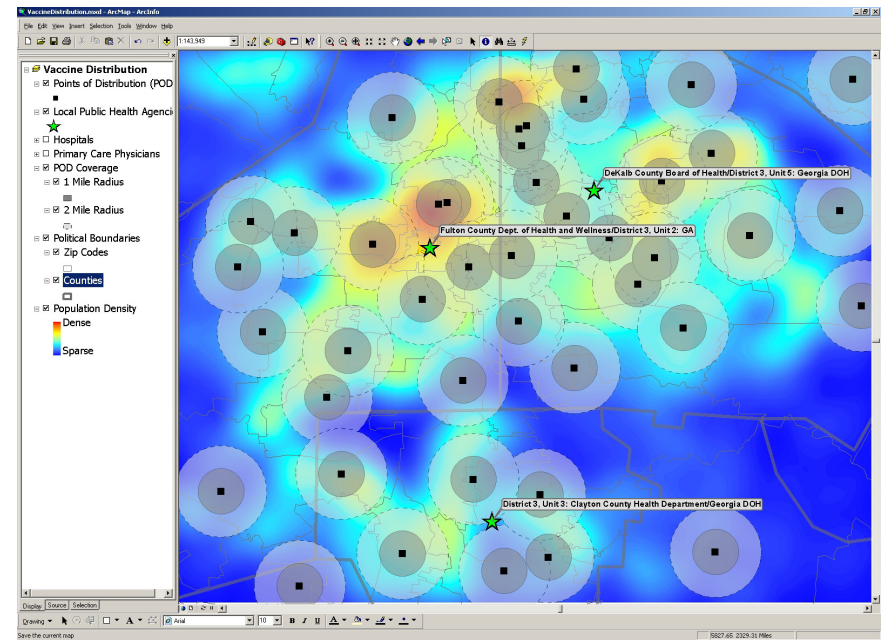
Assessing Levels of Perchlorate Contamination in the Water Supply (Perchlorate is a chemical associated with thyroid disease and cancer.)

Berke suggests that place is another useful "vital sign" to any primary care physician—someone who is concerned about the whole patient. This belief that our places are actually another vital sign is not so hard to grasp when he suggests in the [*Journal of the American Board of Family Medicine*](#), "Recommendations

made in the clinical setting pertaining to healthy lifestyles—more activity, better diets, avoidance of potential toxins or pollutants—cannot occur in a vacuum. If our patients are in a home or work environment that does not give them the opportunity to heed our recommendation, their chance of success will be diminished.” Strong words, but good advice!

Here is where I am on the same page with Hippocrates and Berke: where a person has lived must be considered as part of the context in which clinical decision making occurs. I would add that increasing the transparency and utility of the information on which physicians make recommendations and with which patients are encouraged to comply could change the way we all go about partnering with our personal physicians. So the next time you say, “There is no place like home,” think about its environmental context. The relationship we all have with our home, regardless of its amenities, is unique and potentially harmful to our health because of where that home is located geographically (and perhaps what products were used in its manufacture).

You don’t have to look very far to find the evidence on this subject—just keep reading. While we are typically introduced to our first home shortly after birth and without a choice, our personal and local environment either enhances or diminishes our start in life in many different ways. So our chances of success in achieving lifelong health and wellness are deeply connected to the places we spend those early years. Of course, adults can control many aspects of their local environments. We can choose



This map helps in understanding population density in relation to vaccine distribution centers.

not to smoke or cook over open indoor flames and to use indoor sanitation. But children never get that choice.

A child has to trust someone else (like parents and governments) to protect our air; water; soil; and, in some cases, exposure to things that can harm us. This is a big responsibility! You probably have your own story about geomedicine—unusual health symptoms that can’t be explained; cancers that run in certain families, neighborhoods, or communities; or the onset of chronic conditions that don’t appear to have a genetic or lifestyle link.

Suddenly people start to pay attention to what's around them, searching for anything that might help discover a cause or offer relief or a cure.

Much like a mountain stream has headwaters, so does personal health. Many will say that genetics is our health headwaters, but as the stream meanders across many different geographic landscapes, so does our health, accumulating unseen exposures and facing uncertain and not very apparent risks. The application of geomedicine, then, is about translating what we know about illness and disease, and what we understand about the role that our various environments play in making us sick (or well), into practical information that allows each of us—physician or consumer—to make better choices about where we live and how we engage with our environment.

Answering Questions

What Can Your Address Reveal about Your Health?

Health and medical literature is filled with thousands of studies that link poverty to health status, especially among children and young adults—a preponderance of evidence suggests that a “poor” start in life is a major health determinant. Poverty is not evenly spread across ethnic, racial, or demographic groups, nor is poverty just about how much money people have at their disposal. Sometimes the impact of poverty on health is subtle, such as low-performing public schools with high truancy and low graduation rates, all contributing to poor health.

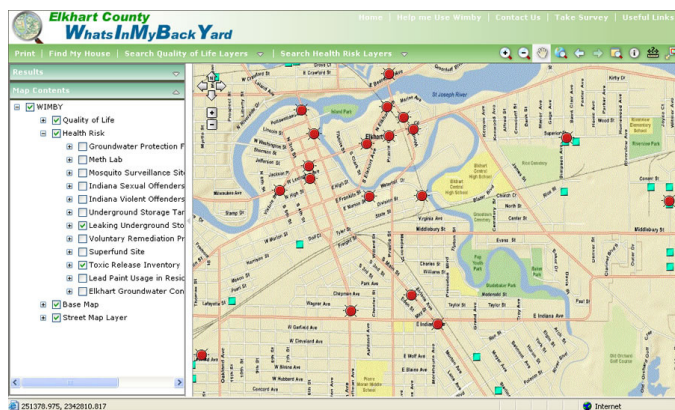
A good example of what I am talking about is the [school performance](#) website created by the *Washington Post* that provides public access to the Washington, DC’s public school scorecards, including their physical and structural adequacy, health violations, and availability of qualified teachers. If education is a marker for the future health of our children, then a physician’s knowing more about the likely educational outcome for a child might inform treatment decisions and ultimately impact a prognosis. Another good example of this type of street address discovery is the New York City Mayor’s Office website that contains a [neighborhood statistics](#) interactive web application.

If you live in New York City, you can enter your street address and get a wealth of information about what is happening in your neighborhood, from public health and safety to education and community resources.

Much like a blood test provides useful clues to underlying health problems that doctors can’t always see at the surface, your street address can also provide valuable contextual information, medically speaking. This is possible because of a vast system of linked data from the US Census Bureau’s enumeration program. This program helps market research organizations better understand what is happening around you—from retail transactions at your local pharmacy to what you and your neighbors like to eat and watch on TV. Specific knowledge about the composition of and likely behaviors hidden within your neighborhood is unlocked when you provide your physician with your street address. A physician advising a patient to eat more fresh fruits and vegetables when there is no grocery store offering these foods within a reasonable distance will probably result in a noncompliant patient.

My argument is straightforward: physicians do not use, for clinical purposes, all the information that patients, like me, routinely

provide (such as street address); they rely only on what they observe and receive in the standard examination. My street address, however, contains important clues about my economic and social context—clues that could help my physician diagnose, treat, and advise me. In fact, my physician could know most of this about me even before I walk through the exam room door!



[Elkhart County](#), Indiana's What's In My Back Yard application gives the public access to information for evaluating potential health risks in their communities. This map shows leaking underground storage tanks (red dots) and Toxics Release Inventory sites (green squares).

The challenge of equipping my doctor with useful, geographically relevant information is great. My physician recently suggested to me that she would have little time for making assessments of such nonclinical information—"just something else to clutter up my charts, and more importantly, I have not been trained to

understand how to use it." And she is right—physicians in the United States don't have adequate information delivery systems or medical training experiences that help them learn how to leverage this type of information. This is where [geomedicine](#) comes into play, by creating new ways to see the patient's surrounding environment—both as it is now and as it was in the past. Accessing and using data that adds intelligence to the medical encounter should be the driving force behind modernizing our health information technology.

When it comes to my health, I want my doctors to use all the information I provide to them—not to be guessing about my ability to follow their instructions and seek recommended treatments and therapies. I want them to be acutely aware of my potential ability in following through with their advice—physically, culturally, and economically. The practice of gleaning valuable information from something as simple as my street address has been around for decades, yet medicine has failed to incorporate it into my medical record in useful ways.

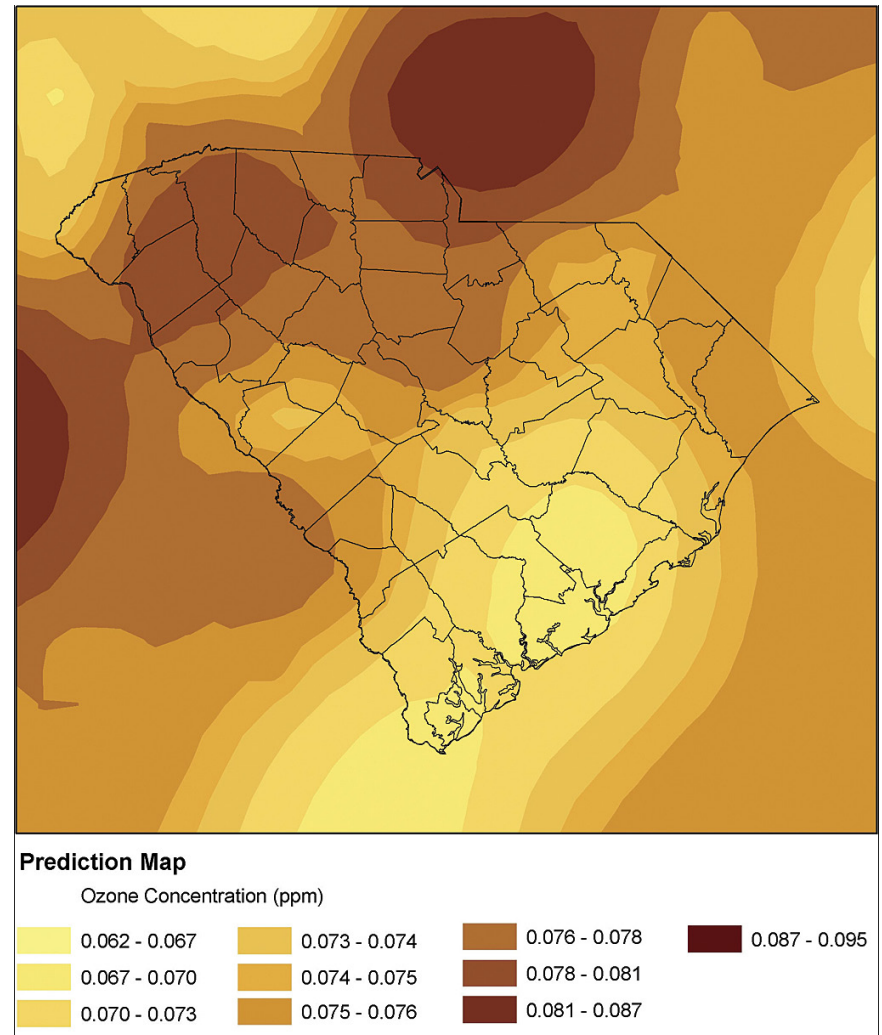
I believe it's time we help health care professionals do this by building into their medical informatics technologies better ways to link to rich data that adds new value. The tidal wave of personal health data that is headed to our doctors' offices as the result of real-time biomedical and environmental monitoring sensors leaves medicine—and my own physician—little choice but to attempt to harness these new data streams to benefit my personal health.

Are There Toxins in Your Home?

Did you grow up in a house that was built before 1978? One progressive community affairs department is linking geographic information to potential environmental health-risk information to help protect young children. If you are pregnant or have children or grandchildren younger than six years of age who will spend any significant time in a house built before 1978, then read on!

Before my sixth birthday, I had already lived in several houses that were built long before 1977, when the US Environmental Protection Agency ban on lead in paint took effect. This means that I am among millions of people who were most likely exposed to unhealthy levels of lead. Most of the lead in my blood probably came from simple things most children do—licking or chewing the painted surfaces of tables, walls, staircase railings, doors, window casings, and toys—or from breathing lead dust generated by sanded or chipped paint containing lead.

I am certainly not alone in having ingested more than a fair share of lead during my first six years of life. Decades later, public health departments around the world are still on an aggressive mission to get rid of this toxic material, particularly from the bodies (and blood) of young children. There are many products that allow lead to get into the blood of a child (e.g., water pipes, cosmetics, imported candies, cooking utensils, painted toys, and dust from making handcrafts). Public health experts go as far as to warn that pregnant women should not remain in a house built



This map shows predicted ozone concentration in the state of South Carolina.

before 1978 that is undergoing remodeling, where old paint may be sanded and dust is not contained.

At last count, more than a quarter of a million children aged one to five years in the United States alone have [unacceptable blood lead levels](#) that are leading to learning disabilities and behavioral problems and, when at very high levels, seizures, coma, and even death. The [State of New Jersey Department of Community Affairs](#) website allows you to check a dwelling address online to see if lead contamination has been detected or is in the process of being cleaned up. In some cases, you can even find out if it's a lead-free dwelling.

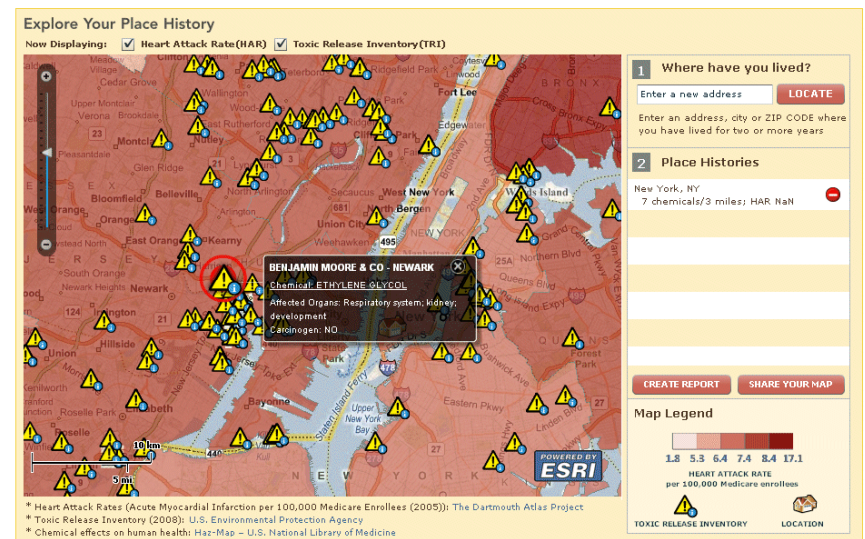
Websites such as this, I strongly believe, are the beginning of the response to the public's demand for environmental health transparency. Such websites usher in a whole new dose of public empowerment. This site validates the notion that geomedicine's chief contribution will be to help people connect the dots and take health knowledge to the next level by linking the *what* to the *where* and *when* at the household level, since this is where much of the clinical knowledge and environmental health impacts become relevant to each of us.

Are There Toxic Chemicals in Your Community?

Over the past several years, I have visited numerous websites and used a number of applications created by government agencies, newspapers, health research organizations, and others, that are

intended to help us better understand our local environments—from water quality and lead poisoning in children to school conditions and local cancer cases. These services help people find out more about the places they live and see the connections between public health issues and their own personal health-seeking interests, embarking on a journey of geomedical self-discovery.

One of these free services is an application that allows you to enter the street addresses of all the places you have lived or worked within the United States. After entering your addresses, you can create a report listing exactly what toxic chemicals are



Using the [Explore Your Place History](#) application, you can view heart attack rates, the US EPA's Toxics Release Inventory, and more, for areas where you've lived and worked.

close to your places. You can access the [place history](#) application using a [web browser](#) or download the application for your [iPhone or iPad](#).

What makes this application unique? While the US EPA and the National Library of Medicine (NLM) have sites that provide citizen's access to data about [hazardous chemicals](#), neither allows building, exploring, saving, or sharing a lifetime place history.

I believe that having a geographically accurate place history, maintained and controlled by consumers, can help inform us and our health care providers about the potential environmental health burdens we all accumulate over a lifetime. As new local health data is published at smaller levels of geography, consumers can come to expect their place history to reveal a wide range of useful information suitable for sharing with their family and their doctors.

In the initial release of the place history application, the locations of the Toxics Release Inventory from the US EPA were mapped against a background showing the death rates for heart attacks in people enrolled in Medicare. I would encourage you to create your own place history and see what you discover. Please also take the time to read the About section of the place history application to learn more about the limitations of the data.

Is Your Local Water Supply Safe?

Unlike all the other nutrients we ingest, water is mandatory—no one can live very long without consuming a certain amount of water on a regular basis. While there is expert medical debate on how much water a person actually requires daily, it is clear that without a reliable supply of clean drinking water, our personal health is surely compromised. Finding information about the quality of your drinking water is not an easy task unless, of course, you already know what you are looking for. It also helps to be a chemist! If you can't find this data easily, do you think your doctor would have any better luck?

I would wager that there is not much water quality information in your medical record unless, of course, you have been treated for waterborne disease. Most of us who live in the United States don't give water quality a second thought—but you might be surprised to learn how water quality varies from city to city.

University of Cincinnati has a [very useful and simple-to-use application](#) that shows the water quality for metropolitan areas across the United States. The site allows visitors to identify metropolitan areas in the United States and discover concentrations of selected chemicals as well as the presence of biologic pathogens occurring in the drinking water of these communities. In many parts of the United States, specific harmful chemicals may dominate a region's drinking water supplies; thus, a physician would be expected to understand what these

differences in water quality could actually mean for diagnosing a particular health problem.

In spite of all the state and federal agencies charged to measure and report on the quality of our drinking water, I could only find one national-level website—the *New York Times* site—that led me to actual water-quality testing data for my city. While the [EPA website](#) has a great deal of useful information, it was more challenging to discover an actual water quality report for my community. I also know that many local communities provide consumer-friendly water quality reports to their citizens, but an interactive website that allows me to compare my city's water quality to another city somewhere else in the United States would be of great value, especially if I am thinking of moving or evaluating the impact of water quality on a specific health problem I am experiencing.

If you're like me, you have lived in more than one house and probably ingested drinking water without knowledge of its quality (other than its color, taste, or smell). I am certain that the tap water I drink and use in food preparation is as important to my health as a lot of other, less conspicuous threats.

Geomedicine is all about connecting environmental information to our personal health and, more importantly, encouraging our personal physicians to use more of this type of information as they work with us to find answers to our health problems. If I am careful enough to live to see my ninety-fifth birthday, I will have

consumed about 3 billion drops of drinking water—about 33,000 gallons, or about 124 tons. Anyway you calculate it, that's a lot of any substance going into anyone's body, and it's certainly worth taking an interest in its quality.

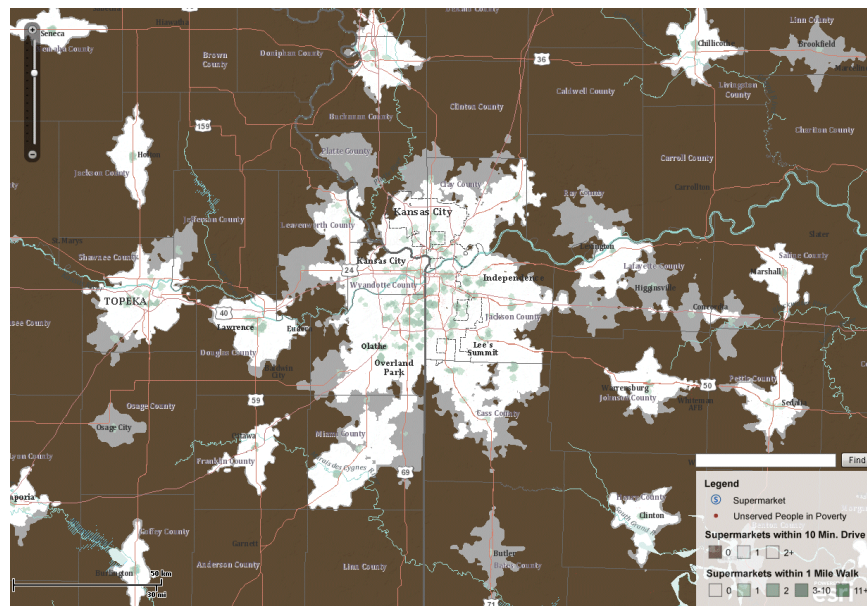
Do You Live in a Food Desert?

To me, better health means eating better and getting enough exercise. Grocery shopping is something most of us do at least once a week. I recently heard a travel host talking about how great it is to be close to three local bakeries, several butcher shops, and half a dozen local grocery stores within an easy 10-minute walk. Of course, this travel host was talking about a large European city; in the United States, most of us don't walk to the nearest grocery store—we drive our cars.

When we do go to the grocery store, we may not even buy wholesome foods—let alone fresh fruits and vegetables. If physical proximity to a grocery store stocked with wholesome food is critical to getting and staying healthy, then it is crucial for us to find a way to be assured that grocery stores are located within easy reach—both physically and financially. Just as we have come to recognize the need to treat unacceptable rates of crime, poverty, or disease and the need for parks and safe places to walk, we should also be considering access to wholesome, quality food at reasonable prices.

Food deserts are defined by the US Department of Agriculture (USDA) as “urban neighborhoods and rural towns without ready access to fresh, healthy, and affordable food.” These deserts are essentially geographic places that lack reasonable access to a grocery store.

Reasonable is a relative term. The 20-something couple living in an upstairs apartment in a large, urban environment may have no problem running through city streets to buy groceries at a store three miles away. However, the retired woman down the hall in the adjacent apartment who had a hip replacement last year may



Megacity's [Food Desert Finder](#) increases the public's awareness of the need to improve food access.

not have the stamina to walk more than a few blocks with heavy bags.

How many food deserts are we talking about? According to the USDA's Economic Research Service (ERS) [report](#), more than 23 million Americans live within a food desert, regardless of whether they live in an urban or rural area. However, physical access to food or groceries can be difficult to measure due to the many factors that create food deserts.

To better understand the problem, two impressive web applications were created to display the geographic locations of food deserts as well as provide estimates of the underserved population by census tract:

- USDA's [Food Deserts Locator](#)
- Megacity's [Food Desert Finder](#)

These interactive maps may help increase the public's awareness of the need to improve food access as well as inform real estate developers and grocery store executives of the geographic demands for better access to wholesome foods.

Johns Hopkins University Center for a Livable Future recently studied Baltimore's food deserts as part of the Maryland Food System Mapping Project. This study noted that although the generally accepted description of a food desert is a residential area that's more than one mile from a grocery store, supermarket, or other food vendor with a variety of fresh fruit, vegetables,

dairy, and meat, most urban planners claim the acceptable walking distance for public transportation is only a quarter mile. Demonstrating the need for such tools, the Johns Hopkins study used a quarter-mile walking distance combined with income data to account for lower-income households, which are unlikely to have a car to drive to the nearest available full-service grocery store.

We all make food-buying decisions based on personal preference and price, but if you're a working, single parent, are you really going to carve out 45 minutes from your evening to prepare sautéed salmon with vegetables and brown rice? Would you be able to find these foods in a corner convenience store? Throwing a frozen pizza in the oven would be a much faster (and less expensive) dinner solution—one that's readily available at most street-corner stores.

It has become increasingly clear that where we live, work, and play are intrinsically intertwined with our health and, thus, with our food choices. Our choice in what we eat is all too often influenced largely by what we see and how hungry we actually feel. Making it easier to see, touch, and purchase better food seems a worthwhile activity that we all can support.

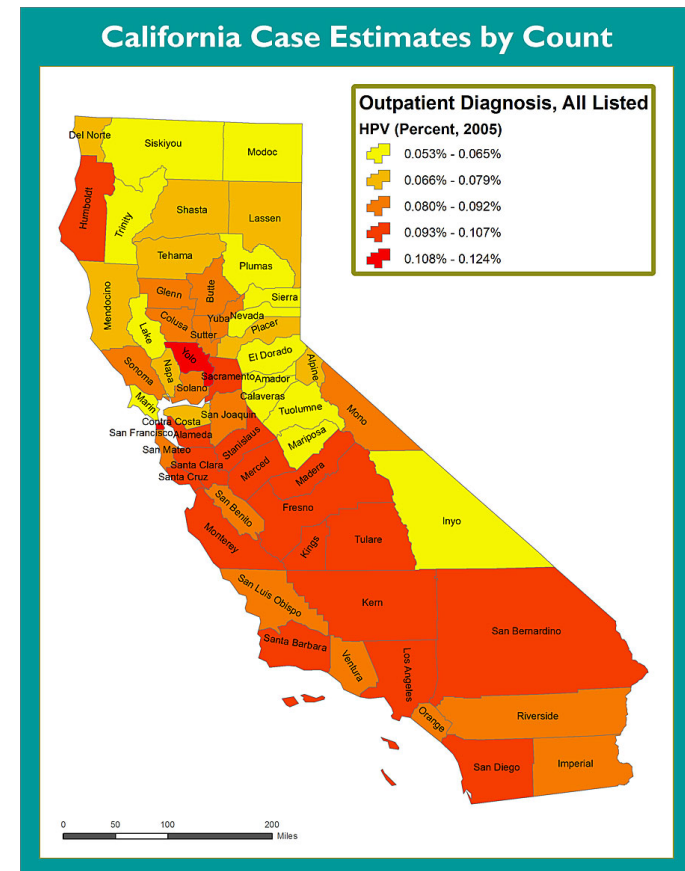
Geomedicine at Work

The Geography of Cancer

Inspired by a bill introduced into the New York State Legislature several years ago, the New York State Health Department has liberated some powerful data about cancer incidences and mapped it at the ZIP Code level. If you don't live in the state of New York but still want to see the incidence of cancers in the [county where you live](#) (there are 3,141 counties in the US), you can visit the National Cancer Institute's website, where every state is represented.

While presenting cancer data at this small geographic level is still very new, the technology behind it is not. In fact, I would expect that as more people learn about this site, there will be a demand for more information sharing—such as cancer incidence rates, more current population data to calculate rates, and interactive graphs and charts to enhance the visitor's overall experience.

Mapping our health geographically is a great opportunity for a health department to begin educating the public in ways that make sense to everyone and not just the needs of health professionals. The site, as you would expect, has several important disclaimers and caveats that visitors are encouraged to read. Nevertheless, knowing more about where cancers actually



Above is a map of California human papilloma virus (HPV) cases by outpatient diagnosis in each county. HPV infection is responsible for 99.7 percent of all cases of cervical cancer.

occur is intriguing. This site engages us and feeds our self-discovery. You might ask yourself why it's taken governments so long to realize the public's interest in looking at this type of data.

Linking geography to personal health using interactive mapping technology at this more useful scale (such as ZIP Code and census tracts in the United States) fuels incredible curiosity about the possible harmful exposures around the places we live and work. It also provides a public window for seeing potential environmental contamination in our communities. So, will we all become "citizen epidemiologists"? Well, perhaps. This could be similar to so many other areas of our society where we have witnessed a "deprofessionalization" of a complex field. Maybe it's health's turn?

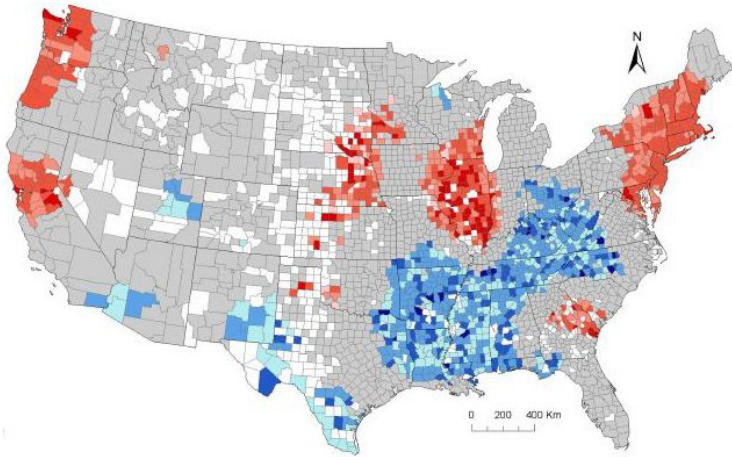
Thanks to the Internet and the development of software applications that demystify complex processes and data—coupled with the public's interest in personal health—public health agencies around the world will experience increasing numbers of curious and tech-savvy health-seeking consumers demanding much more health-relevant data delivered creatively over the Internet. If you are like me, you will wonder why every state does not make cancer data easily available.

Many people will take issue with the validity of exposing small-area cancer data to the average citizen and showing at the same time the exact locations of harmful chemicals regulated by governments. I happen to believe that the more information

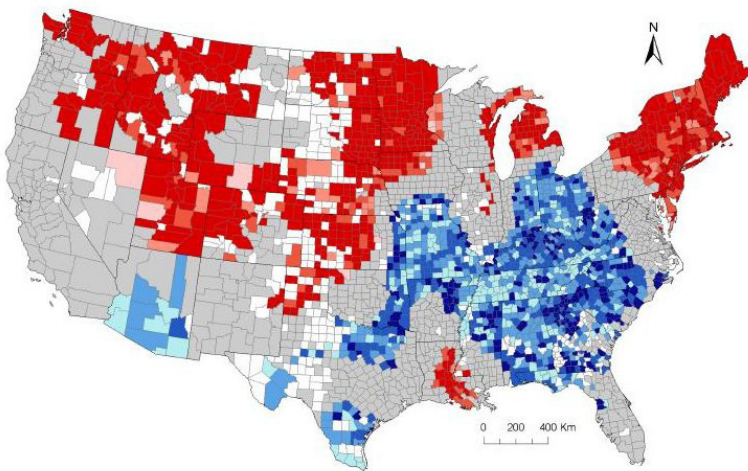
I have about the geographic incidence of cancer, the more informed I am as a health-seeking consumer. What about you?

Mapping Breast and Prostate Cancer Patterns

The emerging field of geomedicine can't move fast enough for many of us who fear the threat of cancer—particularly of the breast or prostate. [In a recently published study](#) that used the geographic microscope, as I like to refer to the geographic analysis of disease, it was found that the incidence of these two cancers is not a random event. While the authors state that they don't exactly know the underlying factors that cause these hot spots—the areas seen in red on the maps—the analysis does reveal the wide geographic variability in where people with these types of cancer live. The maps are compelling because they reveal distinct geographic patterns.



The authors suggest, and you can see for yourself, that both breast cancer (map above) and prostate cancer (map below) cluster geographically, with a strong north–south distribution. You can [learn more about this study](#).



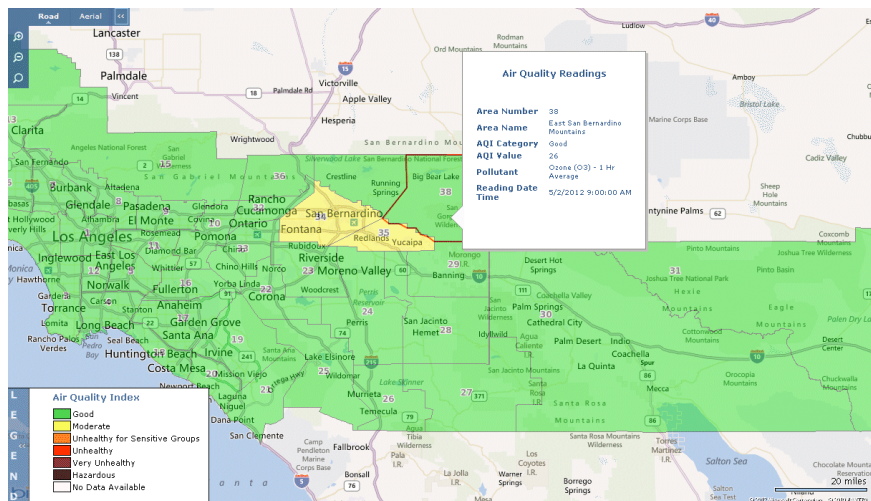
If I lived for more than a couple of years in any one of the red hot spots, I would probably be more proactive in seeking frequent screenings for prostate or breast cancer—wouldn't you?

More alarming to me, however, was the finding that in counties with a high incidence of breast cancer, there was also a high incidence of prostate cancer. The authors suggest that this is happening because these two cancers might have similar or common risk factors (e.g., the environment).

Busy Roads, Air Pollution, and Environmental Health Risks

A number of important studies over the last several years have linked children's respiratory health problems with high densities of vehicular roadway traffic. Using modern geographic mapping techniques, health researchers have concluded that the proximity of roadways to places where children spend a great deal of their day experience higher than acceptable levels of exposure to air pollution.

Presently there are only a few ways parents could check on air quality in their community, and many of these websites don't incorporate modern interactive mapping features. Department of Health and Human Services (DHHS) [secretary Kathleen Sebelius](#) recently declared that DHHS needs to make health data more useful to citizens. Perhaps a good place to begin would be with



The [South Coast Air Quality District](#) website offers air quality information for very broad regions but does not reveal neighborhood exposures.

interactive maps that identify asthma corridors and help parents keep their kids out of them.

I live in the greater Los Angeles area, well-known for its polluted air, so I would expect that the best Internet sites would be based here. But as you will see on the [South Coast Air Quality District](#) site, information is for very broad regions and does not reveal neighborhood exposures or the exact locations of child care facilities, schools, parks, and playgrounds. Hourly traffic volumes are also absent. To add these locations and traffic volumes does not seem to be that difficult, and it would certainly improve the usefulness of the map for citizens.

If you don't live in the Los Angeles area, then you might want to visit the [American Lung Association](#) website, where you can enter your ZIP Code and see a report on the number of people who will likely have some type of health problem triggered by poor air quality.

[AirNow](#), a consortium of international, federal, state, local, and media partners, has a website where you can check out your ZIP Code area and discover hourly air quality—but be sure to read the Frequently Asked Questions section. This air quality map could benefit from more useful, consumer-friendly features and interactive capabilities such as roads, traffic volumes, and satellite imagery.

If the research carried out in California is relevant to other states and communities (and it probably is), the discovery that [child care](#) facilities within 600 feet (the length of two football fields) of a major highway (defined as having more than 50,000 vehicles a day) have more sick kids should be a wake-up call for every community. The research also suggests that about 7 percent of all the California day care facilities and 5 percent of the schools that children under 12 attend are too close to a busy highway.

While this research certainly informs citizens, I wonder why no one has used geographic information technology to estimate exactly how many children might be too close to a busy highway—not just where they attend [child care](#) or [school](#) but also where they actually live. Every time I fly over a large urban area, I

see many [houses and apartments](#) very close to (within 600 feet of) busy highways! If you have ever had a child who had a chronic respiratory illness with symptoms of wheezing and coughing, then you know that having 10 million children across the United States with asthma (about 18 percent of all children under 12 years of age) is unacceptable.

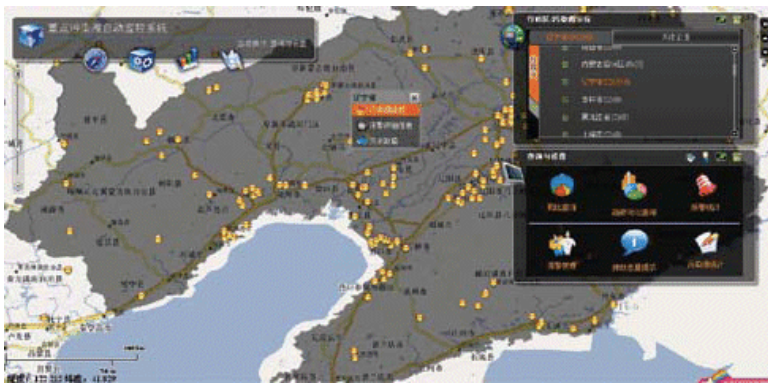
Maybe it's time to rethink our approach as to where we build houses and locate child care facilities, schools, parks, and other places where a large number of children spend a majority of their time—awake or asleep. From personal experience, taking better care of a child's lungs is a far better investment than spending money on treating the lifelong damage that bad air will contribute. The window of opportunity is very small—the first 12 years of life!

In translating public health research into information that helps us all make better choices about where we raise our future generation—our children—we will also come to expect more from those who measure and report on the quality of our air.

Does the Environment Really Matter to Your Health?

GIS and Global Health

The use of GIS is rapidly spreading around the world as one of the most important technologies to help nations address their most serious health goals including reducing disparity in available medical services, improving access to services, and preventing the spread of disease. Striving for ubiquitous health could mean health everywhere, anytime. I acknowledge that health is on a continuum—one does not arrive at good health accidentally. Personal health begins before birth and continues throughout a person's life. Access to health and human services has become one of the major determinants of the degree of health attained.



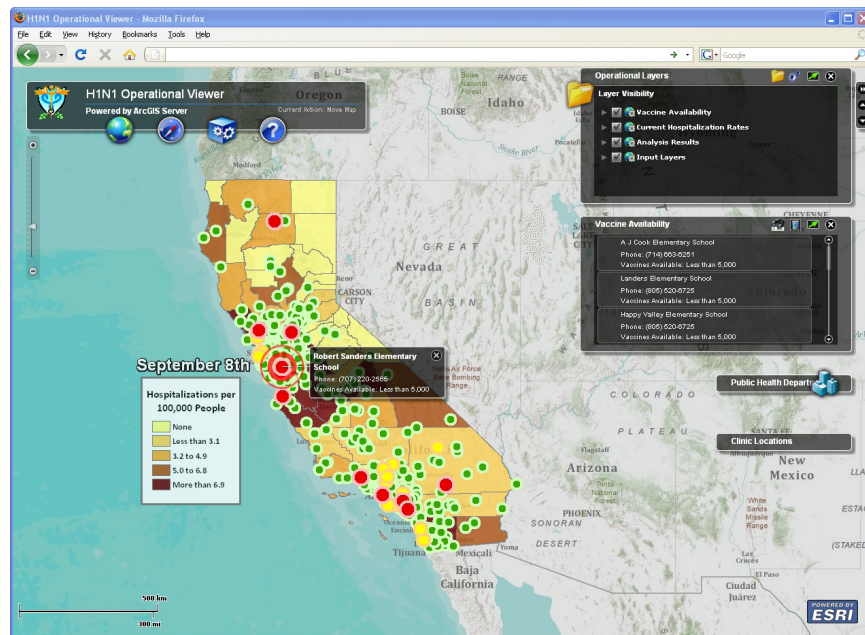
The Ministry of Environmental Protection of the People's Republic of China uses GIS to reveal manufacturing sites.

Multiply one person's health by billions, and this brings us to global health.

The strength of modern GIS technology extends well beyond geographically relevant data analysis and powerful data visualization. It excels as a medium that helps inform, organize, and deliver health and human services. GIS supports every web-based service locator, directions-finding website, and consumer-facing information and referral service sponsored by health organizations.

As nations strive to protect their citizens from the threat of infectious diseases such as legionella, dengue fever, West Nile virus, tuberculosis, or avian influenza, GIS has become an important technology for adding intelligence to existing disease surveillance systems at the local, regional, and national levels. GIS technology's ability to author, publish, and share critical information about the spatial dynamics of disease makes it, without exception, the technology of choice for accelerating the detection and identification of disease clusters. GIS technology's capacity to reach beyond geopolitical boundaries makes it highly desirable in public health emergencies and responses.

As every person is different, so too is every community and nation. However, the various ways that information technology is used seem fundamentally parallel. The ways in which GIS is used by health and human services organizations are more similar than dissimilar; therefore, one of the greatest promises of GIS is its ability to speak a common language. In my opinion, developing a common language about health and human services helps nations move forward.



This H1N1 Operational Viewer lets health officials and the general public track influenza cases.

The adoption of any information technology is ultimately a function of its ability to produce results such as creating evidence, identifying inequities, better informing decision makers, and aiding more responsive actions and interventions to protect human health.

Today, more than 129 (65%) national health ministries located across every continent use some type of GIS technology. In developing nations where modern information technology is resource challenged, GIS technology is being deployed in the form of specialty epidemiological software distributed at low or no cost to health professionals through organizations such as the World Health Organization, Pan-American Health Organization, and the US Centers for Disease Control and Prevention (CDC).

As GIS technology continues to enjoy wider adoption in health and human services organizations across all types of government and private health care organizations, knowledge about our communities—especially how our local environments impact our personal health—will command greater attention by community leaders everywhere. The ability to respond to emergencies and prepare citizens for disasters, such as pandemics, cannot be overlooked or underresourced in regard to information systems.

Global health begins at home. The obligation of nations to help citizens have a safe, healthy passage through life is neither a small nor simple matter. Dedication by health professionals in building effective systems and practices must be supported by evidence

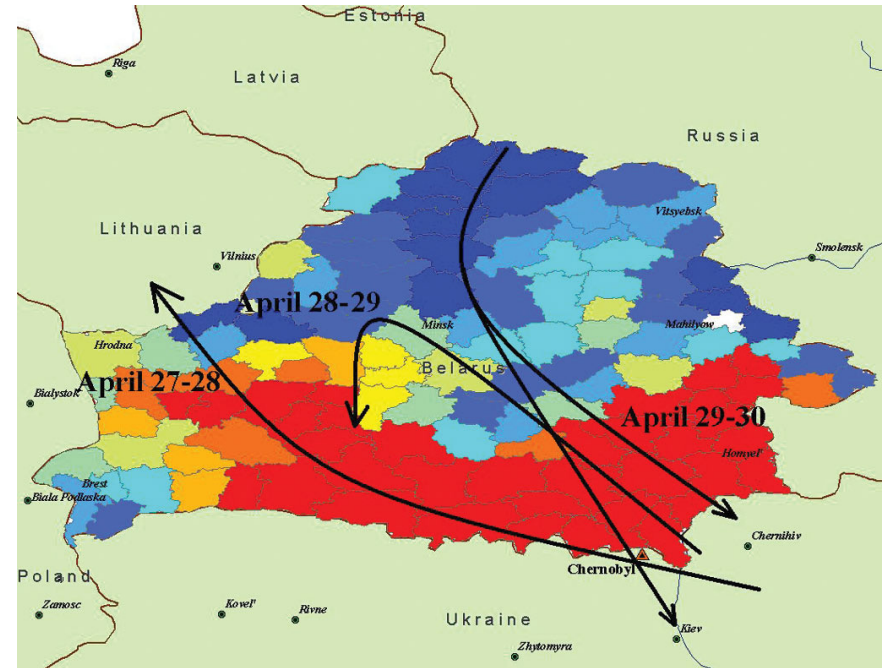
and results. It also takes knowledgeable people and progressive technologies to promote confidence in the information that is communicated.

Delivering on the goal of global health requires unrelenting devotion to leveraging today's knowledge technologies to mitigate the problems we face today. GIS will certainly play a large role in moving communities and their nations forward, and when we move forward, everyone everywhere has a better chance to attain the desirable health that is so needed in the world.

Evaluating Geomedicine

The geomedicine idea has recently been receiving a lot of attention—at [TEDMED 2009](#), Microsoft's [Health Tech Today](#), the [Huffington Post](#), and elsewhere. This exposure has led to many interesting and thought-provoking comments about geomedicine and the larger question of the importance of environment to health. I'd like to address some of the comments and concerns here.

Some have felt the evidence of relationships between our environment and human health was marginal, at best, while others have stressed its importance. One reader mentioned the vastness of the "evidence" in the scientific literature about the harmful effects of environmental contamination on human health, while others took issue with the notion that our environments are



This analysis examined the probability of thyroid cancer rates in children in Belarus as a result of the Chernobyl nuclear reactor explosion.

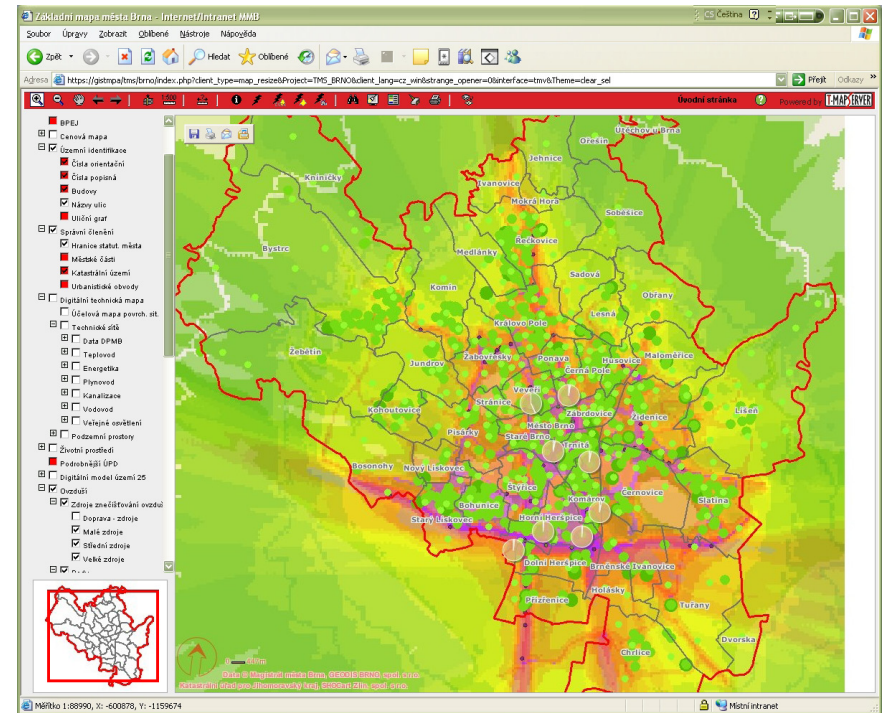
as important as lifestyles or genetics. Several comments warned that knowing more about the potential hazards of environmental impacts on health would only promote more lawsuits.

One comment in particular that caused me to flinch was a suggestion that people with limited economic opportunities and less access to medical care tend to live in less healthy places. This, if it is really true, would have huge societal implications. Which

comes first—bad health or unhealthy communities? Do you think that the poor are naturally drawn to less healthy places?

A physician commented that my personal story overreached the environmental impacts on my health, suggesting, however, that the idea of creating a place history had merit. Some people wished for solid evidence (correlations and causation) in what I had to say. Even the comments that were critical of the strength of environmental evidence were supportive of the idea that society should get busy cleaning up known compromised environments. Much to my surprise, there were many comments that reflected people's concern over government's role in watching society too closely and the potential abuse of this type of information or its analysis by health insurance companies and governments to deny coverage or otherwise limit our economic opportunities.

It was also suggested that if your physician thinks your symptoms reflect an environmental cause, then he/she would certainly ask you more about your personal geographic place history. Many agreed on the value of creating a personal place history, and many others shared stories where they believed overlooked environmental factors could potentially explain a personal health event or condition. One physician said that this idea is “an incredibly commonsense approach [that] could help unveil risk factors from your past and potential health issues to look out for.”



Analysis of Air Pollution by the Brno City Municipality
(Courtesy of ARCDATA Praha, s.r.o.)

This doctor suggested that patients should tell their doctor if they think they have been exposed to a toxic substance. While I certainly agree with that advice, it is often what we don't know and see in and around our environments that is the most harmful to our health. In general, comments reflected a growing awareness of the potential impact of environmental factors, and most felt it was smart to try to use all the available information when it comes to understanding what makes them sick.

The recent news stories of the identification of a long-term pediatric cancer cluster in Florida by the US CDC and of the contaminated well water and soil from the long-term disposal of hexavalent chromium in a rural Pennsylvania community by the US EPA have people worried. One thing these events have in common is the need to discover the many people who lived near this contamination long before it was identified as a potential threat—thus, a compelling need for an accurate personal place history linked to our electronic medical record.

In my opinion, those who are building electronic health records—supposedly for the benefit of patients and health-seeking consumers—must make sure we have a reliable way to link our personal place history to the sophisticated electronic health records they are building now.

The Future of Geomedicine

A key element in the growing acceptance of geomedicine will be the exploitation of the body of research produced by the health science community. Also critical will be the ability to build and organize relevant medical content that links place to health conditions, risks, and outcomes. For example, research examining the impact of ambient air quality on cardiovascular and respiratory disease is under way in many nations of the world, and research is confirming that a patient's health is related to proximity to high-volume roadways, an idea being examined using GIS. There is a substantial body of scientific literature that

describes the impact of geographic location on health problems such as cancer, diabetes, hypertension, and osteoporosis, and the importance of place is becoming better understood.

A key element of the acceptance of geomedicine by physicians will be the usefulness and accessibility of this body of research.



Also critical is the ability of medical libraries and health research organizations to make their data holdings accessible over the Internet. Integrating a patient's place history into existing

electronic medical and personal health records is one of the principal roles of today's geographic "expert" system. Just as the collection of family medical history helps clinicians look for certain predispositions to diseases, geographic place will provide the context within which the clinician can assess environmental factors and make judgments about diagnosis, treatment, and prognosis.

Much like the capabilities of lab systems to make clinicians aware of "panic values," GIS can provide the same early warnings to suggest to clinicians environmental factors to be explored. Geomedicine has the potential to transform the way physicians see patients and to provide a more holistic view of the many hidden factors that often defeat achieving successful long-term health outcomes.

Bibliography

Artz, Matt. "Relating Geography and Health Care: An Interview with Bill Davenhall." *Geospatial Today*, July 2010.
geospatialtoday.com/gst/index.php?option=com_content&view=article&id=870

Berke, Ethan M. "Geographic Information Systems (GIS): Recognizing the Importance of Place in Primary Care Research and Practice." *Journal of the American Board of Family Medicine*, January–February 2010.
<http://www.jabfm.org/content/23/1/9.full.pdf+html>

Conn, Joseph. "Data-Driven: HHS Taps into Treasure Trove of Info." *ModernHealthCare.com*, June 7, 2010.
<http://webcache.googleusercontent.com/search?q=cache:pVb6nM5tXv0J:www.modernhealthcare.com/article/20100607/NEWS/100609968>

Davenhall, Bill. "Spatial Medicine to Better Health." *Geospatial Today*, March 2007.
esri.com/library/reprints/pdfs/geospatial-today-health.pdf

Davenhall, Bill. "Your Health Depends on Where You Live." TEDMED 2009.
ted.com/talks/bill_davenhall_your_health_depends_on_where_you_live.html

Davenhall, Bill. "Helping Shape Global Health." *ArcUser*, Winter 2010.
esri.com/news/arcuser/0110/global-health.html

Davenhall, Bill. "Geomedicine: The Missing Link in Our Personal Health History." *Huffington Post*, February 5, 2010.
huffingtonpost.com/bill-davenhall/geomedicine-the-missing-l_b_451148.html

Davenhall, Bill. "Geography—The Missing Vital Sign in Your Physician's Office." *Huffington Post*, March 11, 2010.
huffingtonpost.com/bill-davenhall/geography---the-missing_b_494479.html

Davenhall, Bill. "Does the Environment Matter to Your Health?" *Huffington Post*, April 14, 2010.
huffingtonpost.com/bill-davenhall/does-the-environment-matt_b_535041.html

Davenhall, Bill. "Environmental Health Watch: Are There Toxins in Your Home?" *Huffington Post*, May 13, 2010.
huffingtonpost.com/bill-davenhall/environmental-health-watc_b_568628.html

Davenhall, Bill. "Cancer Maps: The Power of Geomedicine at Work." *Huffington Post*, June 7, 2010.
huffingtonpost.com/bill-davenhall/environmental-health-canc_b_599524.html

Davenhall, Bill. "Busy Roads, Air Pollution and Environmental Health Risks." *Huffington Post*, July 24, 2010.
huffingtonpost.com/bill-davenhall/environmental-health_b_653493.html

Davenhall, Bill. "Is Your Local Water Supply Safe?" *Huffington Post*, August 26, 2010.
huffingtonpost.com/bill-davenhall/water-quailty-in-your-med_b_685548.html

Davenhall, Bill. "Geomedicine: What Your Street Address Can Tell Doctors about Your Health." *Huffington Post*, September 28, 2010.
huffingtonpost.com/bill-davenhall/your-street-address-can-i_b_737308.html

Davenhall, Bill. "Geomedicine: Using Geographical Information Systems to Improve Personal Health." Paper submitted for the Bridging Public Health Informatics with Personal Health Records: Opportunities for Wellness and Disease Prevention session of the Tenth International Conference on Information Technology and Applications in Biomedicine, November 3–5, 2010.

Davenhall, Bill. "Toxic Chemicals in Your Community? A New App Will Let You Know." *Huffington Post*, November 9, 2010.
huffingtonpost.com/bill-davenhall/my-place-history-explorin_b_779166.html

Davenhall, Bill. "Geomedicine Shows Patterns in US Breast and Prostate Cancer." *Huffington Post*, February 7, 2011.
huffingtonpost.com/bill-davenhall/post_1663_b_817254.html

Davenhall, Bill. "Do You Live in a Food Desert?" *Huffington Post*, August 29, 2011.
huffingtonpost.com/bill-davenhall/food-deserts_b_937277.html

Green, Rochelle S.; Svetlana Smorodinsky; Janice J. Kim; Robert McLaughlin; and Bart Ostro. "Proximity of California Public Schools to Busy Roads." *Environmental Health Perspectives*, January 2004.
<http://ehp03.niehs.nih.gov/article/info:doi/10.1289/ehp.6566>

Houston, Douglas; Paul Ong; Jun Wu; and Arthur Winer. "Proximity of Licensed Child Care Facilities to Near-Roadway Vehicle Pollution." *American Journal of Public Health*, September 2006.
<http://ajph.aphapublications.org/doi/pdfplus/10.2105/AJPH.2005.077727>

Mandal, Rakesh; Sophie St-Hilaire; John G. Kie; and DeWayne Derryberry. "Spatial Trends of Breast and Prostate Cancers in the United States between 2000 and 2005." *International Journal of Health Geographics* 8 (2009): 53.
<http://www.ij-healthgeographics.com/content/pdf/1476-072X-8-53.pdf>

McConnell, Rob; Talat Islam; Ketan Shankardass; Michael Jerrett; Fred Lurmann; Frank Gilliland; Jim Gauderman; Ed Avol; Nino Künzli; Ling Yao; John Peters; and Kiros Berhane. "Childhood Incident Asthma and Traffic-Related Air Pollution at Home and School." *Environmental Health Perspectives*, July 2010.
<http://ehp03.niehs.nih.gov/article/fetchArticle.action?articleURI=info%3Adoi%2F10.1289%2Fehp.0901232>

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About the Author

Bill Davenhall has worked in the health and human services field since the early 1970s, during which time he has directed many different initiatives that involve the progressive use of information systems within health care and human-services delivery organizations. Davenhall is a frequent speaker and writer and is well known as one of the leading advocates for the use of GIS to help solve the challenges in health and human services. He earned a master's degree focused on medical behavioral science research from the University of Kentucky. Davenhall is a senior health adviser for Esri, working part-time from his home near Phoenix, Arizona.



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