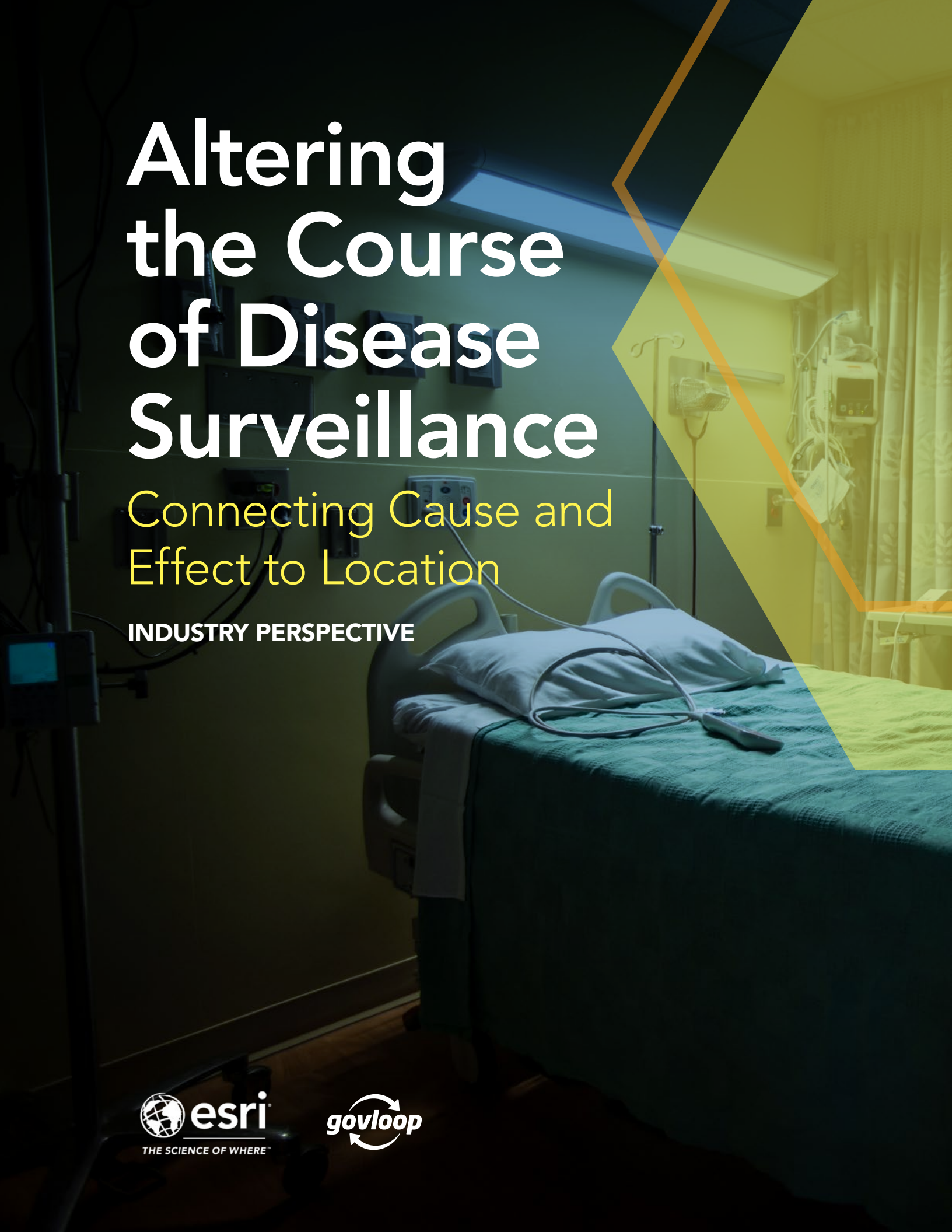

Altering the Course of Disease Surveillance

Connecting Cause and Effect to Location

INDUSTRY PERSPECTIVE

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Introduction

Disease surveillance is our first line of defense in protecting the health of our communities. Today, the need for disease surveillance as a practice is becoming heightened. There has never been a greater need for providing epidemiologists with the resources and tools to better predict, monitor and communicate.

At the same time, health organizations have never had as much data at their disposal to monitor, analyze and respond to outbreaks as they do today. But simply collecting large volumes of data isn't enough. Government health organizations also need data analytical tools to really transform their efforts in disease surveillance and make data-driven decisions.

The time to change course and modernize how we think about disease surveillance is now. Location has always been a critical foundation for connecting location of outbreaks to the source and spread. Geographic Information Systems (GIS) are critical to an integrated approach to collecting information, analyzing patterns, communicating the results and monitoring progress.

GIS is a powerful technology that can be used for early disease detection and timely response. It can help stakeholders at all levels – local, regional and national – understand disease patterns, share information easily and make data-driven decisions by aggregating and mapping various data sources.

The ability to efficiently visualize and analyze data, such as climate and environmental factors or issues like West Nile, and determine how they affect the spread of the disease, can slow or even prevent an outbreak. To further understand how organizations can use GIS to improve disease surveillance and the health of their communities, GovLoop partnered with Esri, a leader in GIS technology, for this report. This report was informed by Esri health experts and features success stories of governments effectively using GIS for disease surveillance.

How GIS Supports a Disease Surveillance Information System

Historically, organizations turned to GIS to map, track and understand the scope of health issues affecting their community. They've been able to use GIS to organize the substantial amount of data they collect, and use new data in real time, to inform decision-makers.

Disease surveillance is one such area that can support a collaborative approach by GIS and a location-based strategy. The web GIS pattern promotes a collaborative environment and connects disease data early enough for organizations to take effective action. The earlier the detection of an epidemic or disease, the greater the odds of its successful containment.

To do this, health organizations must rethink workflows and identify where gaps are in which GIS can and is providing value.

GIS aids response by helping share information on emerging disease threats and what is causing them to stakeholders at all levels. GIS can help in planning disease surveillance activities and reducing costs associated with the necessary interventions by predicting outcomes before financial commitments are made. It also helps with prioritizing the allocation of resources.

Additionally, GIS provides a common platform for multi-disease surveillance activities. Standardized epidemiological data can place disease surveillance data in context with information on demographics, the environment, administrative boundaries and more.

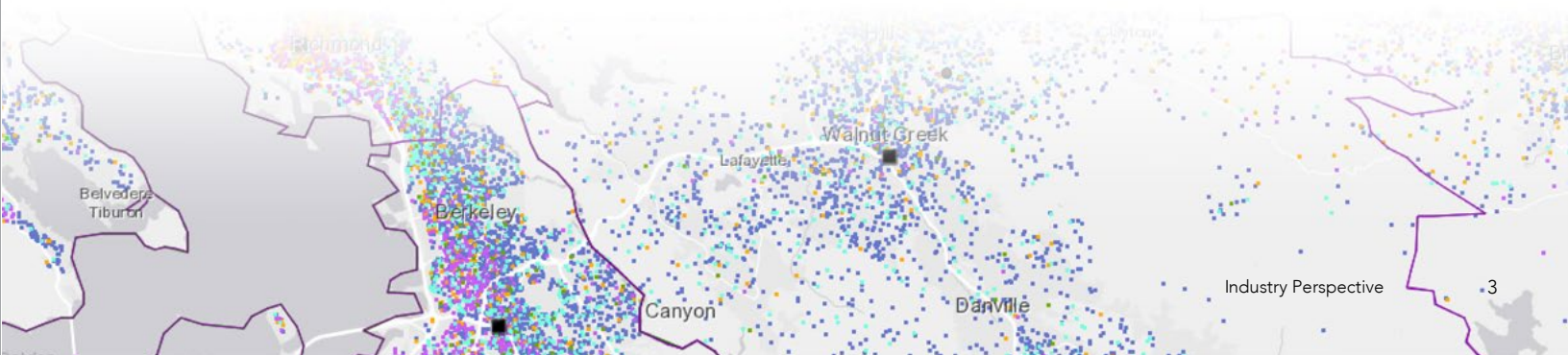
GIS also shows information on disease occurrence at a variety of scales, from regions to individual cases. Mapping graphically portrays the distribution and pattern of disease and the intensity of an outbreak.

This information can be related to the locations of service providers, customers, resources and programs. The dynamic link between databases and maps provided by GIS means that updates to data are automatically reflected in dashboards, maps and apps.

Additionally, the latest advancements in GIS technology have made the work of disease surveillance efforts even more comprehensive and effective in the following ways:

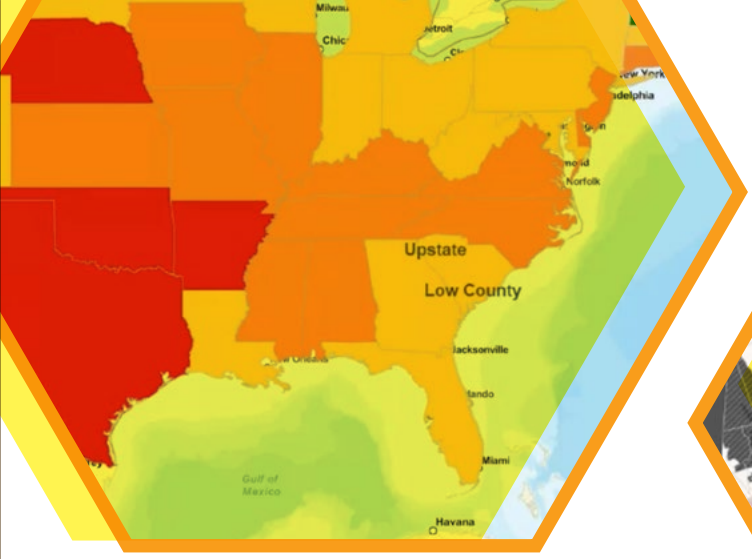
- Professional mapping is now provided in an intuitive user interface that advances visualization, analytics, image processing, data management and integration.
- Scientific analytical tools are also now available to identify patterns, make predictions and answer questions, and you can connect to your data directly and use maps, charts and tables to perform basic to complex analyses that scale based on skill level and meet mission need.
- Communication tools can help better inform officials and the public about outbreaks or other relevant information.
- Data can be collected using mobile devices and sensors and then organized for quick analysis and collaboration.
- Finally, cloud-based GIS technology lets your maps scale so hundreds or even thousands of people can interact with them at the same time.

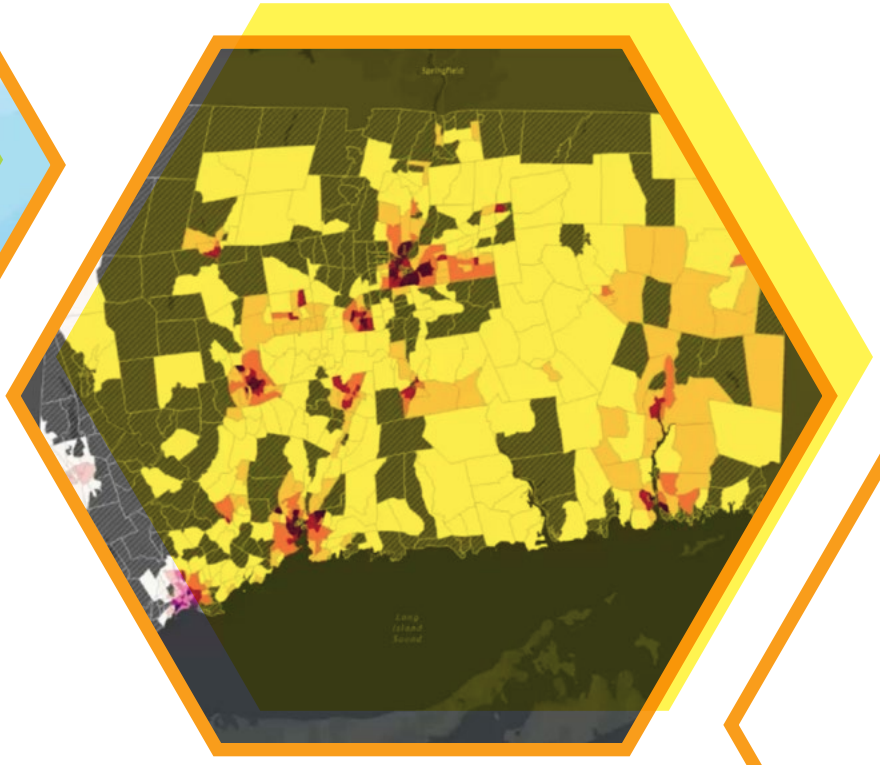
These new GIS advancements enable organizations to make the most of their data, driving better decision-making and ensuring the public remains healthy and safe.



4 Key Areas of Disease Surveillance Work

In order to transform disease surveillance and leverage GIS tools, there are four steps that organizations must take: collecting data, preparing data, analyzing data and predicting trends. Let's take a closer look at each.





1. Collecting and Integrating Data

Finding and leveraging useful data from which to work is the first step in enhancing your disease surveillance efforts. Public health organizations collect a substantial amount of data, but the data often remains in silos. Fortunately, a variety of other data sources exist that can be used to enhance your disease surveillance programs. Data can be collected from a variety of places, depending on what you have access to, with the more common ones being through the electronic death registration system, the national electronic disease surveillance system, lab reports and medical records.

GIS can be the system to integrate the vast amounts of data your organization collects. A huge percentage of data has a geographic component, which serves as a common language, bringing all that data together for analysis.

Above is a map that shows statistics on the previous flu season, highlighting where the highest percentage of confirmed cases were located. It demonstrates leveraging data from a variety of sources by combining to layer on desired information about influenza. Using different data sources on a map like this can help you more quickly understand when the flu rate is likely to be highest so you can deploy resources at the right time.

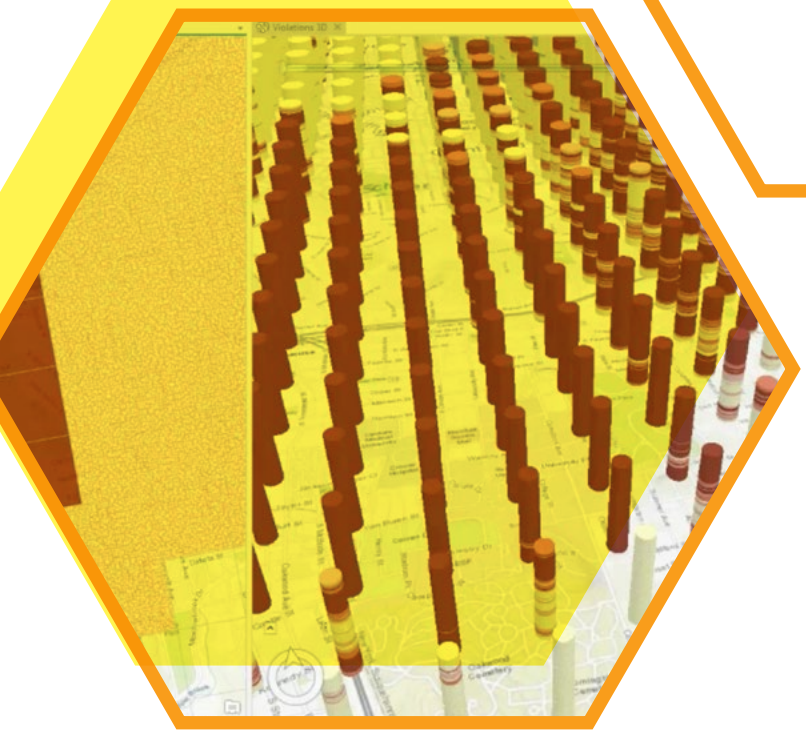
2. Preparing Data

The second building block, and perhaps the most critical, is preparing data for analysis. Essentially, this means ensuring the data you are using for analysis is valid because error-prone systems and data can negatively affect detection.

This includes auditing your data for errors and anomalies, enriching raw data and linking sources. Tasks often include projecting data, reducing the spatial extent to the area of interest, deleting unneeded attributes, creating new attributes and more. Preparing data means ensuring that datasets can be validly analyzed together and reducing processing time as much as possible.

Preparing data can often involve transforming data between different formats and scales and filling in different gaps. But how can you prepare your data correctly if you're missing some critical items? Esri is working to infuse machine learning and artificial intelligence into many aspects of its software to help address these challenges. In particular, machine learning can play a critical role in spatial problem-solving in a wide range of application areas.

The above image shows a web map predicting asthma hospitalization rates.



3. Analyzing Data

Analysis of your data answers questions about what's happening and where, how fast a potential spread of a disease is occurring and what factors are accelerating or preventing the spread.

Esri's ArcGIS mapping and analytics software allows you to visualize and analyze your data in terms of its location on the map. You can enhance your data with content from a variety of sources and stakeholders. With this better analysis, stakeholders at all levels are empowered to make better decisions that are truly data-driven.

The map above demonstrates analysis of 3D models, which include data on both space and time, allowing for the cause of disease to be tracked. GIS technology enriches your data with demographic and census information that will help determine the best way to respond.

4. Predicting Trends

Finally, GIS can help organizations with predicting where diseases could spread and what populations will be impacted, so they can be proactive.

All of this combined allows you to consume all these rich sources of information and analytical tools that are available to help make better decisions related to disease surveillance activities. A geospatial approach, integrated with operational data, creates verifiable processes to better manage current projects and formulate future predictions.

The map below uses known parameters affecting mosquito distribution, along with satellite imagery, navigation technologies and mobile communications to help predict mosquito presence, abundance and risk. The resulting map shows the likelihood of mosquitos in any given area, which can then be used to help strategize mosquito eradication efforts.

Disease Surveillance in Action: **Case Studies**

New York City Department of Health and Mental Hygiene

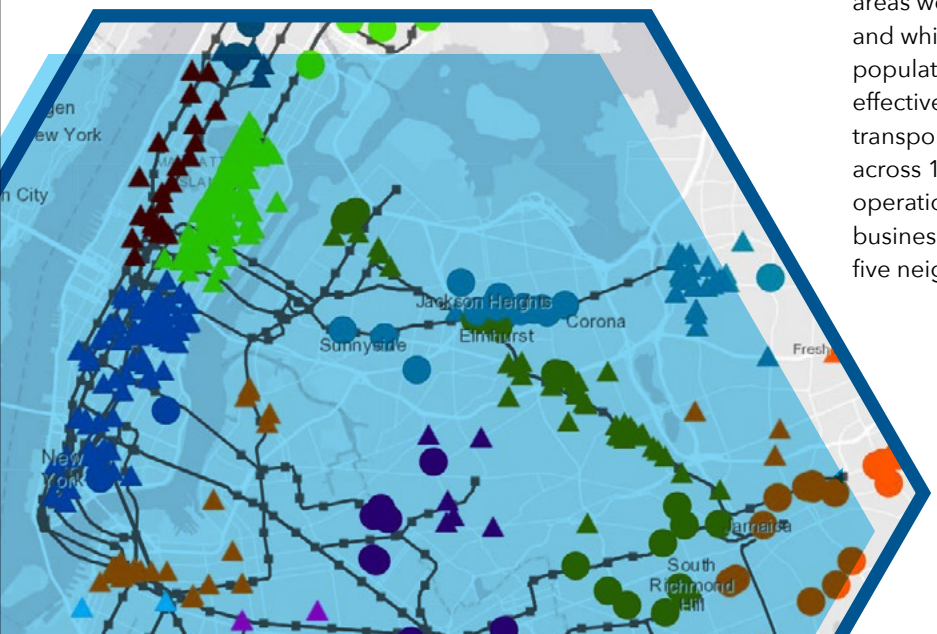
The challenge: The New York City Department of Health and Mental Hygiene's mission (DOHMH) is broad-ranging, from administering inspection grades for dining establishments to mitigating infectious disease outbreaks. With over 7,000 employees serving more than 8 million citizens, DOHMH is one of the largest public health agencies in the world. Given its size and scope, DOHMH needed an efficient and savvy way to prepare for Zika as it was threatening the United States. Since New York City is a major travel hub, DOHMH staff knew they had to prepare for potential Zika virus outbreaks – even before local mosquito-borne cases were identified in Florida. To do this, they needed to identify populations potentially at risk and reach out to obstetrics and gynecology (OB-GYN) providers in these neighborhoods. To ensure messaging was getting to patients, DOHMH needed to canvass 178 OB-GYN clinics with very limited resources (11 two-person teams in one business day using public transit).

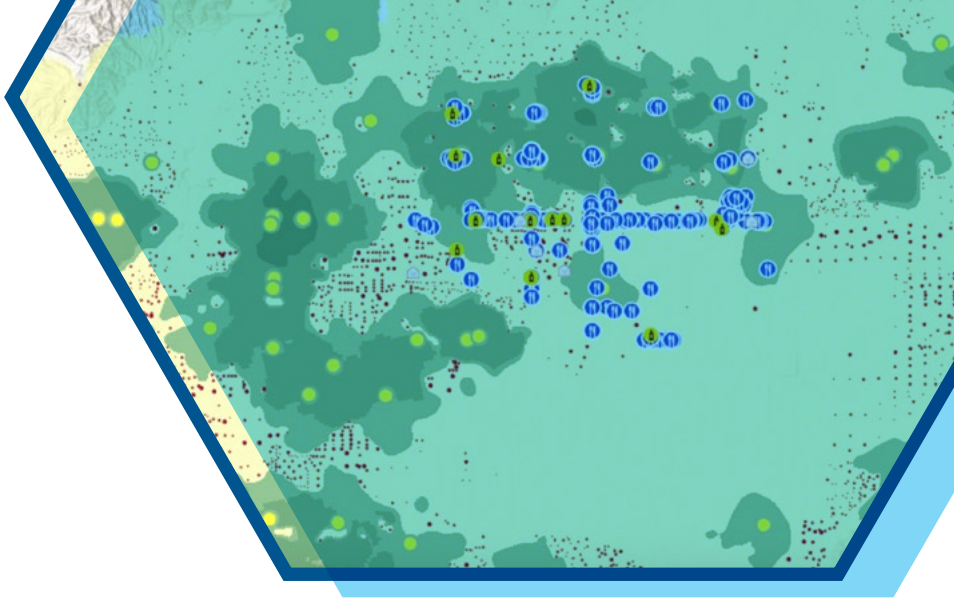
The solution and outcomes: Led by Dr. David E. Lucero, Director, Data Unit, DOHMH staff used Esri® ArcGIS technology to identify at-risk neighborhoods. With ArcGIS, they developed a risk index using the following data layers:

- Population density of first-generation immigrants in New York City from Latin American countries where there is local Zika virus transmission
- Water and tree canopy density in New York City – since mosquitoes, the vector of the Zika virus, may aggregate in these areas
- Density of arboviral (infections caused by viruses spread by infected insects) cases for the past three years in New York City

Next, using spatial analysis, clinics were assigned (and, therefore, travel routes optimized) for canvassing teams. The analysis assigned clinics to a team by minimizing travel distance to public transit stations, public transit routes and at-risk neighborhoods.

With this approach, they were able to predict which areas were most at risk of local Zika transmission and which clinic locations would likely service at-risk populations. They could then allocate resources more effectively. In one business day, 11 teams used public transportation to visit a total of 178 OB-GYN facilities across 10 neighborhoods. A subsequent canvassing operation yielded similarly effective results; in half a business day, four teams visited 70 facilities across five neighborhoods.



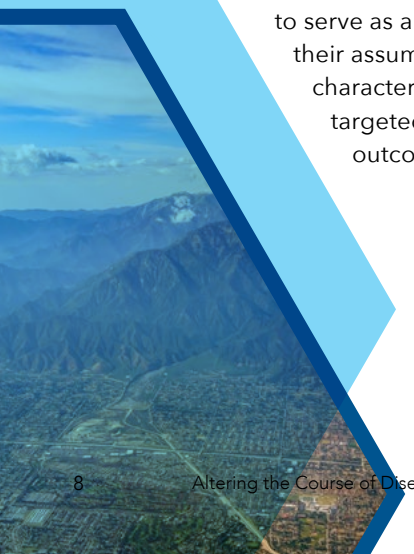


Rancho Cucamonga and Increasing Healthy Lives

The challenge: In 2008, Rancho Cucamonga faced the sad fact that the health of their citizens was declining. Obesity and diabetes were on the rise, a phenomenon occurring in many cities and towns across the United States. In response, the city developed the Healthy RC initiative, a citywide collaborative comprised of dedicated residents, community organizations, and public and private entities working together to make Rancho Cucamonga the healthiest it could be. The collaborative used available data to prioritize those areas with the highest chronic conditions and the least amount of resources.

As with most cities, the location and composition of neighborhoods can represent significant disparities between incomes and access to healthy food and care. The citizens living in one neighborhood could have limited or no access to healthy amenities such as parks, farmer's markets, and grocery stores, while nearby, people had opportunities for healthy lifestyles. One area could be seen as dangerous or unsafe for children to walk to school. Another may have community gardens not available to people living close by. Even zoning, which determines the type of permitted land use, could contribute to negative health effects for some of the population.

Perhaps the biggest hurdle to getting the data the city needed was reaching out and engaging the citizens themselves. They needed to do in-person health surveys to provide the granularity of localized data needed to better understand the lives of citizens in different parts of the city and to serve as a baseline for ground-truthing their assumptions about neighborhood characteristics, and ultimately developing targeted strategies to improve health outcomes.



The solution and outcomes: Using ArcGIS, a mapping and analytics platform, the Healthy RC collaborative first analyzed neighborhood level data and identified the most disadvantaged areas, where health issues were highest and access to healthy options was lowest. Next, they compared those areas with poverty and median income data to better understand the disparities between different parts of the city.

To establish a baseline, the team created a paper-based survey they could take into the field and interview people going door-to-door. They also held community events and went to city parks and trails to connect with their community as well as deploying an online survey.

With this initial set of new information entered in ArcGIS, they were able to quickly determine areas where it is difficult to purchase affordable, healthy food, also known as food deserts. Using maps, they could see where existing sidewalks, grocery stores, and parks were and were not. To learn where the areas were considered unsafe, they connected the data with the survey information, crime data, and other community stories.

Bringing all this information together in ArcGIS allowed the city to investigate how current zoning was impacting neighborhood health and how changes to the zoning could benefit different neighborhoods.

Ten years later, a report showed that childhood obesity had decreased by 13 percent; overweight students decreased by 7 percent; heart disease decreased 20 percent; diabetes decreased 14 percent; and cancer decreased by 21 percent.

Kaiser Permanente and Diabetes Mapping

The challenge: More than 1 million Americans are diagnosed with diabetes every year. Though diabetes can be well-managed with proper treatment, people who do not manage the condition well may develop uncontrolled diabetes, which causes dangerously high blood glucose.

At the Kaiser Permanente (KP) Napa-Solano Family Medicine Residency Program in California, Dr. Ruben Gonzalez and Dr. Juleon Rabbani teamed up with KP GIS analysts and local public health students to evaluate whether distance to their medical centers had an effect on uncontrolled diabetes (hemoglobin A1c at 9 percent or higher) in their patient population.

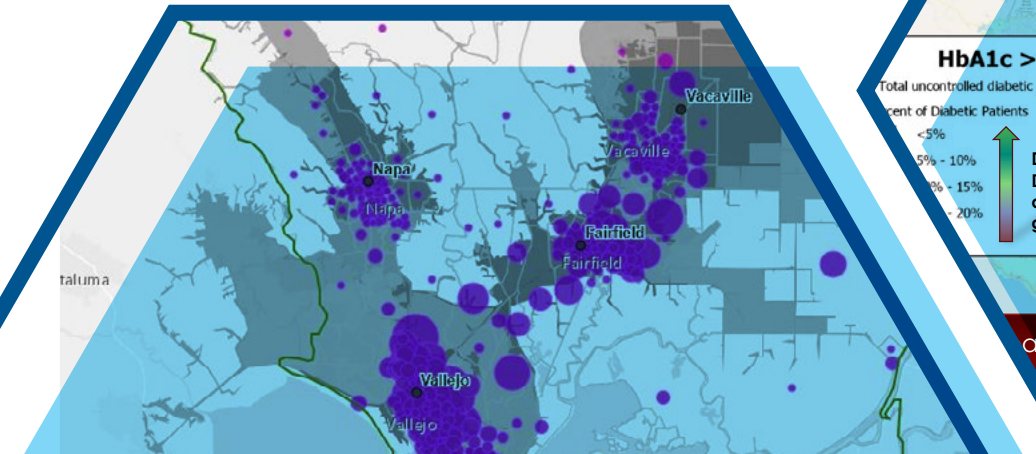
"We were interested in understanding if there are geospatial variations in people who have uncontrolled diabetes in our community," said Rabbani, Graduate Medical Education Research Project Manager and epidemiologist at Kaiser Permanente. "There's some indication in the literature that proximity to medical services can affect health outcomes. And because we're an integrated health system with comprehensive electronic medical records, we're able to link objectively collected health data to geocoded patient addresses."

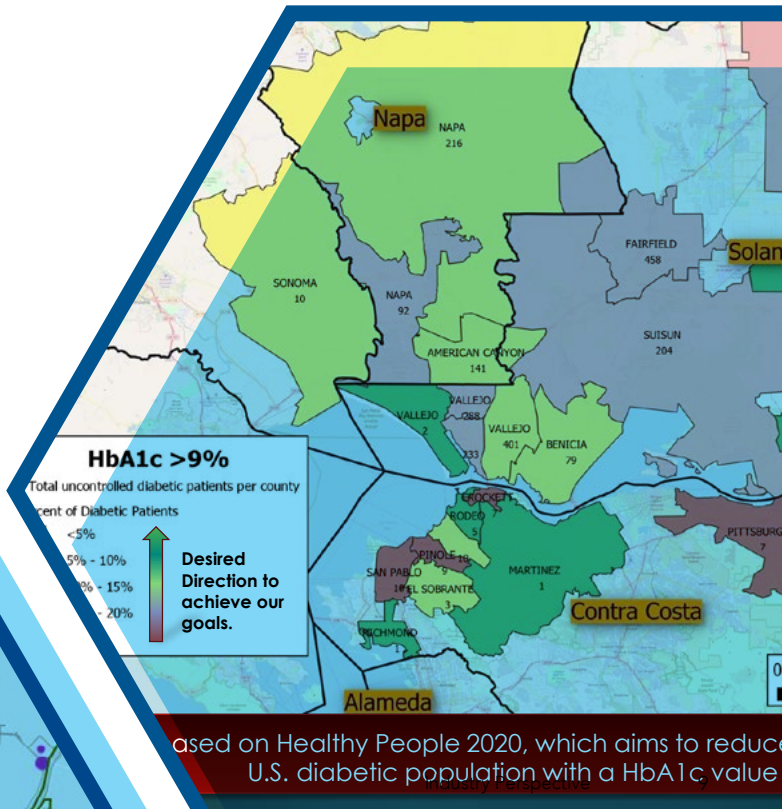
The KP team realized that GIS technology and capabilities, including spatial analyses and data visualizations, are increasingly important tools for tracking chronic diseases and determining appropriate interventions. They decided to apply GIS visualization techniques to see if proximity to their medical centers seemed to have any effect on diabetes management in their community. Their GIS data is examined in the aggregate, and individual patients' personal health information is kept private.

The solution and outcomes: Gonzalez and Rabbani's team created an interactive map that layered 15- and 30-minute drive increments to their four regional medical facilities, and then overlaid that with a depiction of the uncontrolled diabetics in their community. Though there were too many other potential factors to conclusively say that distance from centers truly played a part in a patient's diabetes management, the initial project gave indications that it could have some effect.

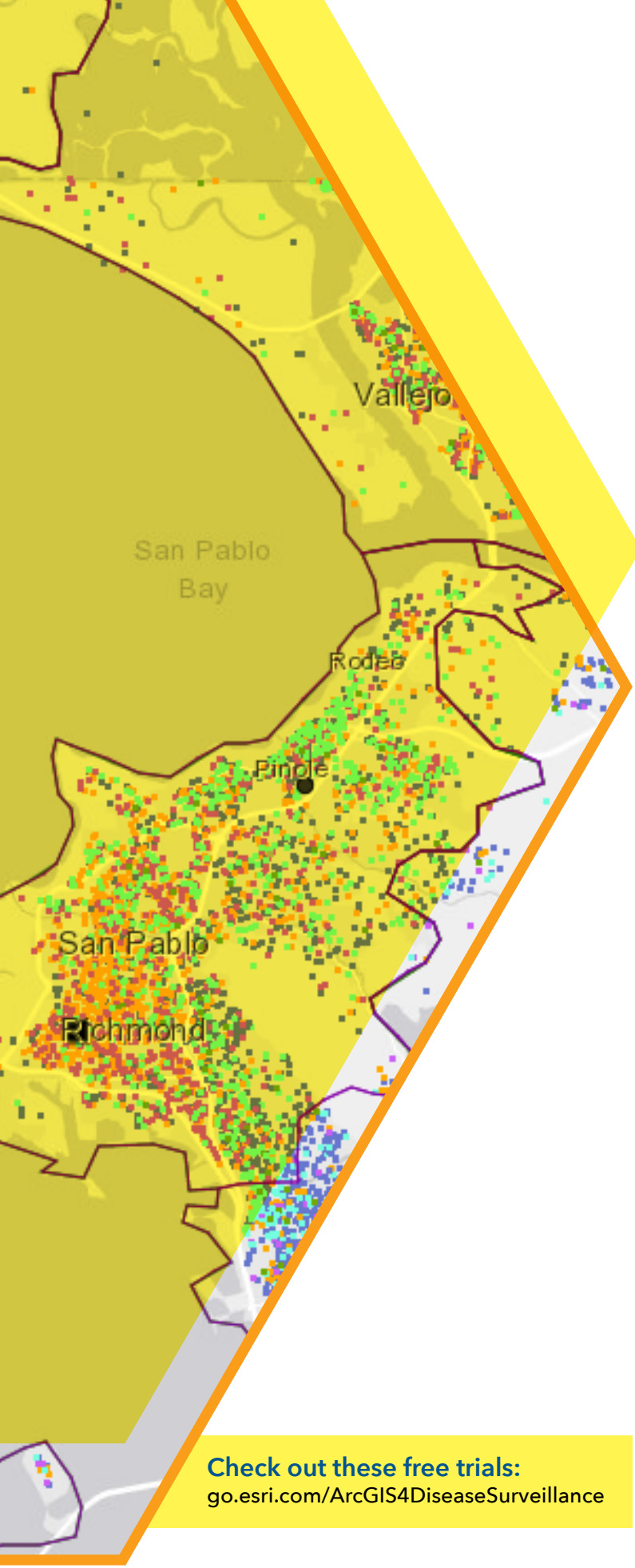
The project has also helped clinicians and decision-makers at KP recognize that quality improvement initiatives like this can benefit from spatial epidemiology; spatial epidemiology can be an effective communication and decision-making tool in applied health care settings; and to accomplish this, trained multidisciplinary teams and established workflows are needed to succeed.

"Next we'll bump this up to a full-blown research project and will create a prediction model to quantitatively assess drive time and proximity to the nearest medical facility," Rabbani said. "This will allow us to understand if these factors are statistically significantly associated with having uncontrolled diabetes, after controlling for several patient demographics and clinical factors."





ased on Healthy People 2020, which aims to reduce
U.S. diabetic population with a HbA1c value



Getting Started

Are you ready to integrate GIS into your disease surveillance strategy? Asking these simple questions can make sure you're getting started on the right path.

Is your disease surveillance workflow current and ready to be revolutionized?

GIS can help you manage processes, software and data products in real time through standardization, centralization and repeatability, allowing you to improve production efficiencies and save resources in your workflows.

Are you leveraging web GIS?

Web GIS supports real-time visualization and analysis and provides a flexible and agile framework for implementing GIS as a platform. Make sure you are maximizing your investment by looking for innovative ways to leverage your web GIS system internally.

Have you explored the availability of analysis tools?

The way you display data on a map can change the patterns you see. Spatial analysis tools allow you to quantify patterns and relationships in the data and display the results as maps, tables and charts. The analysis tools empower you to answer questions and make important decisions using more than a visual analysis.

Have you explored the availability of lifestyle and demographic data?

GIS maps and data available can give you access to a valuable and insightful collection of demographic, psychographic and socioeconomic data, with over 15,000 data variables from 130-plus countries.

Check out these free trials:
go.esri.com/ArcGIS4DiseaseSurveillance

GIS Supports the Needs of Disease Surveillance Today

When disease outbreaks occur, fast, effective response is essential to help protect people from infection and its consequences. Temporal and spatial information are critical to those efforts to curb the spread of disease. Organizations that harness the power of a location platform can achieve a faster, more efficient response, as well as track the spread of a disease over time.

When GIS tools are applied toward disease surveillance and control, agencies are able to address some of their toughest challenges. That's possible because location is a key dimension in those challenges: Identifying where things are happening, how the disease spreads geographically and how to allocate limited resources across a region to perform surveillance and treatments saves time, money, and most importantly, lives.

When Esri was founded in 1969, we realized even then that geographic information system (GIS) technology could make a difference in society. Working with others who shared this passion, we were encouraged by the vast possibilities of GIS.

Today our confidence in GIS is built on the belief that geography matters - it connects our many cultures and societies and influences our way of life. GIS leverage geographic insight to ensure better communication and collaboration.

Explore our website to discover how our customers have obtained the geographic advantage by using Esri software to address social, economic, business, and environmental concerns at local, regional, national, and global scales. We hope you will be inspired to join the Esri community in using GIS to create a better world.

Check out these free trials:
go.esri.com/ArcGIS4DiseaseSurveillance

GovLoop's mission is to inspire public sector professionals by serving as the knowledge network for government. GovLoop connects more than 300,000 members, fostering cross-government collaboration, solving common problems and advancing government careers. GovLoop is headquartered in Washington, D.C., with a team of dedicated professionals who share a commitment to the public sector.

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