Technologies for Vector-Borne Disease Surveillance

When a vector-borne disease outbreak occurs, rapid response is critical for minimizing the impact on a community's health. A geographic information system (GIS) is a computer-based tool that public health agencies can use to visualize outbreak data and efficiently share real-time information and resources with field and operational staff to make better decisions that lead to cost savings and improved community health outcomes.

This document features resources that can help public health agency staff:

- Identify technologies that can be used to monitor and mitigate outbreaks.
- Conduct individual activities that comprise a surveillance workflow.
- Learn best practices to support better decision-making at the local and state levels.

Disclaimer: ASTHO does not endorse any of the products featured in this document. These technologies were selected because they are largely platform agnostic and interoperable, and because several state health agencies have demonstrated their effectiveness for decision-making.

Elements of Surveillance Workflow

A surveillance workflow simply refers to the configuration of surveillance applications and tools into a sequence of connected steps. Some of the most common tasks in a vector-borne disease surveillance workflow include data collection, data analysis, and visualization to carry out mosquito adulticide planning, monitor mosquito populations, and carry out service requests. If an agency is already conducting vector-borne disease surveillance activities, adding or upgrading tools can make the current workflow more robust. These tools can be free or open-source, commercial, or a combination of both. However, public health agencies not yet conducting surveillance activities can also explore ready-made workflow solutions. For example, agencies can use a GIS such as Esri's ArcGIS Online or QGIS.

Tool	Developer	Offline Data Collection	Cost
Fulcrum	Fulcrum	Yes	$22+ per monthly user
Survey123	Esri	Yes	Free with ArcGIS Online subscription[1]
Collector	Esri	Yes	Free with ArcGIS Online subscription

Data Collection Tools

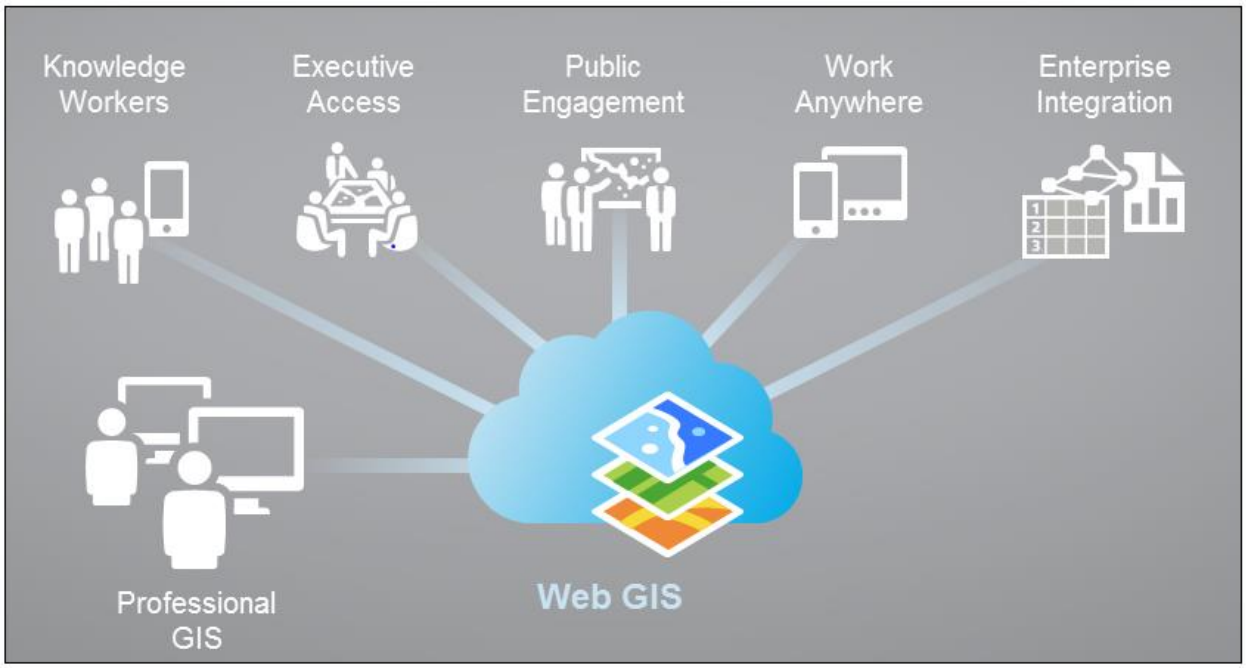
Form-centric survey tools such as Fulcrum's data collection tool and Esri's Survey123 allow users to customize surveys and collect data using a smartphone or tablet. Users can attach geotagged photos and upload them to a database in real time, and map-centric tools like Esri's

[1] https://www.esri.com/en-us/arcgis/products/maintenance

Collector allow users to capture and edit geographic information on a map. Free trial versions for these tools are available.

Geographic Information System Platforms

Although desktop and web-based GIS provide similar functionality, a web-based platform is hosted on a vendor's servers or cloud, allowing users to interact with data through a browser from any location or device. A desktop GIS can restrict analysis and data management to a user's desktop, which can be advantageous for ensuring data privacy, but can also be connected to a web-based GIS for data sharing.



A GIS desktop user can connect to a web-based GIS to create and share content and, in turn, use layers shared to the web-based GIS by knowledge workers and the public. (Esri, 2019)

Quantum GIS (QGIS): QGIS is a free, open-source desktop GIS whose functionality compares to leading commercial software. QGIS is able to consume data in all formats, can export data into other GIS programs like Esri and Adobe Illustrator, boasts multi-language support, and supports plugins for additional functionality. As an official project of the Open Source Geospatial Foundation, QGIS has no associated licensing costs and is supported by a group of volunteers who add to its growing capabilities, initiatives, and resource library.

ArcGIS Pro*: ArcGIS Pro is Esri's desktop GIS product that supports data visualization, advanced analysis, and authoritative data maintenance in both 2D and 3D. Integrated within the ArcGIS platform, it supports data sharing across ArcGIS Online and ArcGIS Enterprise through web-based GIS and includes built-in apps to enhance data collecting and sharing and improve operational efficiencies. It is available in several licensing levels that each provide additional functionality to the same core applications, user interface, and development environment.

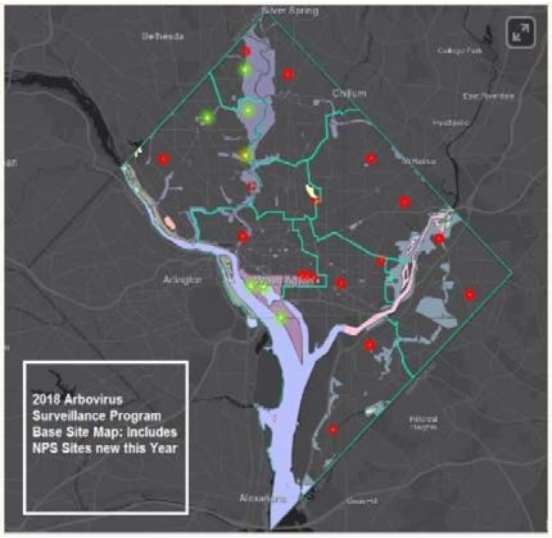
ArcGIS Online* ArcGIS Online is a commercial web-based GIS developed by Esri that provides desktop users with access to online maps, data, and services to supplement their content. It is built upon the concept of cloud-based mapping and analysis, which allows users to share and collaborate using maps and data across various locations. Users can integrate this GIS with dozens of additional applications, like Survey123 or Collector, and use the ArcGIS Story Maps application to share their products with non-GIS users on smartphones and tablets.

CDC's Epi Info: Epi Info is a free epidemiologic software package that CDC designed for the global public health community of practice and research. Its tools allow users to design forms for data collection, create and analyze databases, and visualize data on maps and dashboards. CDC also developed an Epi Info vector surveillance mobile application that vector control staff can use to collect and send data to an analysis dashboard, where staff can review summaries and visualizations in real time. Epi Info also includes a GIS mapping feature called Epi Map that displays geographic data in choropleth or dot density maps. While Epi Info boasts over one million global users, its software only works on a Windows operating system.

*Esri solutions can exist on vendor servers, private servers, and a public or private cloud. These programs include options that allow users to collect protected health information.

Fight the Bite: Protecting the District of Columbia from Mosquitoes

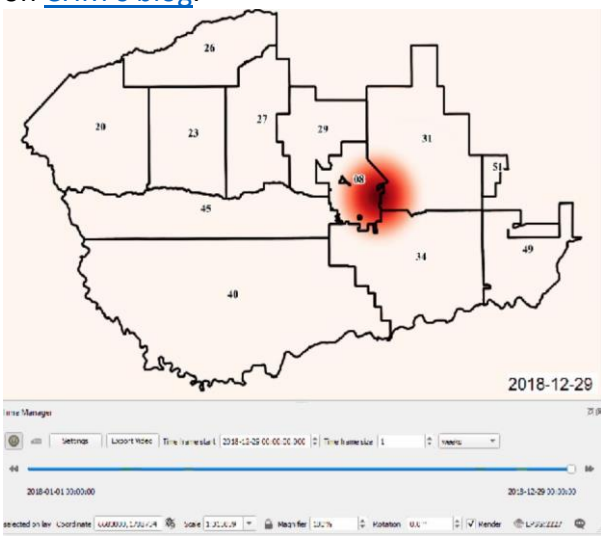
In 2016, in response to the Zika outbreak, the District of Columbia Department of Health (DC Health) substantially increased its mosquito monitoring activities throughout Washington, D.C. Through a collaboration with the National Gallery of Art, DC Health used Esri's ArcGIS Online software to improve how it targeted populations at risk for Zika and help the arboviral team surveil and mitigate the mosquito population. This enabled the team to plan its mosquito trap placement and share the measurement results. Fieldworkers also used Esri's Survey123 tool to collect more information, which could be automatically shared back to ArcGIS Online for analysis. Online and mobile mapping replaced DC Health's manual mapping methods, which increased efficiency and made it easier to share information with other agencies and stakeholders. Learn more on about this case study and explore data on DC Health's story map.



In 2016, DC Health used ArcGIS Online to accurately map mosquito trap sites and breeding grounds, which led to a more thorough reading on mosquito populations and potential health risks in the area.

Community Health Maps Develops Open-Source Mosquito Surveillance Curriculum

In 2019, the Community Health Maps (CHM) program, a collaboration between the National Library of Medicine and Birds Eye View GIS, held two vector-borne disease surveillance workshops for state and territorial health agency staff. Using mosquito data from Madera County, CA, CHM developed an original curriculum that instructed participants on analyzing and visualizing mosquito trap data and generating surveillance products like heat maps and animate temporal data for outbreaks using the QGIS platform and plugins. The workshops were developed through a partnership between CHM and ASTHO. Learn more about the success of the workshops and access the mosquito surveillance curriculum on CHM's blog.



Animated data of mosquito population using the QGIS Time Manager plugin.

Vector-Borne Disease Surveillance Workflows

Agencies with access to Esri's licenses can configure Esri maps and apps (included with a license and integrated into the ArcGIS platform) to support their vector-borne disease surveillance. These configurations range from field operations solutions, like conducting aerial spraying, to outreach solutions, like engaging with communities to mitigate an outbreak. The platform connects mosquito control, public health staff and the public, leading to improved decision making, response time, and dispatch efforts. For more information, see Esri's Interactive Story Map and Esri's 2016 white paper.

For agencies that lack access to paid software, the Community Health Maps Initiative (CHM) has developed a surveillance workflow using free and low-cost open-source data collection and mapping tools. CHM specifically designed this workflow to empower local communities to collect, manage and share their own data. The workflow uses the QGIS platform (which consumes all data types) and is interoperable with the Esri platform and national databases, such as CDC's Behavioral Risk Factor Surveillance System. CHM delivers online workflow training and hands-on workshops at partner events.

As public health agencies plan for mosquito season, a well-established surveillance strategy is critical to successfully preparing for an outbreak. The tools and technologies explored in this document aim to strengthen an agency's ability to conduct targeted control measures to mitigate the spread of local transmission, effectively communicate with the public, and inform policymakers to make better decisions for the communities they serve.

For more guidance and resources regarding vector-borne disease management, please visit ASTHO's Natural Environment web page.