



TOBACCO WHERE YOU LIVE:

# Mapping Techniques

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U.S. Department of  
Health and Human Services  
Centers for Disease  
Control and Prevention



# ACKNOWLEDGEMENTS

This brief was produced for the Centers for Disease Control and Prevention by the Center for Public Health Systems Science at the Brown School at Washington University in St. Louis.

## Primary contributors:

Stephanie Andersen, Laura Brossart, Rebecca Ballard, Amy Endrizal, Rachel Hackett, Zara Petković, Douglas Luke

## Input was provided by:

Nicole Aune, Caren Bacon, Todd Combs, Elizabeth Courtney-Long, James Cucinelli, Kathy Gallagher, Courtney Heck, Sally Herndon, Rick Hull, Maria Julian, Dierdre Kittner, Jim Martin, Mollie Mayfield, Kari McFarlan, Jennifer Park, Lisa Richidt, Andrew Romero, Karla S. Sneegas, Jennifer Ullman, Brenna VanFrank, Mandi Zanto

## Other contributions:

Photos on page 4 and 17 courtesy of National Cancer Institute

Photo on page 10 courtesy of ASPIRE Center

Photo on page 13 courtesy of Multnomah County

Photo on page 19 courtesy of Montana Tobacco Use Prevention Program

Photo on page 20 courtesy of North Carolina Department of Health and Human Services

## Suggested citation:

Centers for Disease Control and Prevention. *Tobacco Where You Live: Mapping Techniques*. Atlanta, GA: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, Office on Smoking and Health, 2022.



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# OVERVIEW

## Tobacco Where You Live

Clear evidence exists about what works to reduce commercial tobacco use at the population level.<sup>1</sup> Yet, many states and communities across the country have not implemented effective strategies.<sup>2,3,4</sup> Groups disproportionately impacted by tobacco industry targeting and social determinants of health continue to experience high rates of tobacco-related disease and death.<sup>5</sup> Understanding community needs and using community-driven solutions can inform how to move toward closing these gaps in commercial tobacco prevention and control.

The goal of **Tobacco Where You Live** is to empower tobacco control program managers, staff, and partners to understand how commercial tobacco use varies within their communities, overcome challenges, and reduce disparities. Each Tobacco Where You Live brief will cover a topic important to reduce commercial tobacco use in communities with the highest prevalence.

When this guide references commercial tobacco or tobacco products, it refers to products that are mass-produced and sold for profit. This is separate from the sacred and traditional use of tobacco by some American Indian communities.

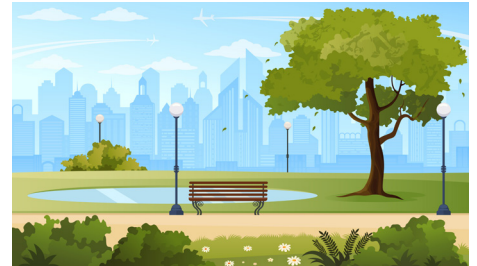
## In this Resource

**Mapping Techniques** focuses on how to create, share, and use commercial tobacco prevention and control maps. Mapping allows programs to focus their efforts where they can have the greatest impact. Maps can help you:

- Understand community trends and show disparities
- Find gaps in program and policy implementation
- Educate decision makers and the public
- Model potential strategies
- Evaluate interventions

## About the Project

**Tobacco Where You Live** is a Best Practices User Guide resource. The Center for Public Health Systems Science at Washington University in St. Louis is developing a set of resources to translate research into practical guidance for states and communities. These resources expand on the evidence-based guidelines and funding recommendations in Centers for Disease Control and Prevention's (CDC) **Best Practices for Comprehensive Tobacco Control Programs—2014** (Best Practices 2014).<sup>6</sup>



## Best Practices User Guides

*The Best Practices User Guides project is funded by CDC contract 75D30120C09195. Its contents are solely the responsibility of the authors and do not necessarily represent the official views of CDC. References to non-CDC sites and the use of advertisements and images do not constitute or imply endorsement of these organizations or their programs by CDC or the U.S. Department of Health and Human Services. CDC is not responsible for the content of pages found at external sites. URL addresses listed were current as of the date of publication.*



# MAKE THE CASE

Maps show where people **live, work, and play** at a point in time. In tobacco control, maps show patterns in commercial tobacco use and access to tobacco products, where interventions have been implemented, or how patterns have changed over time. Maps can support many stages of your work, from early planning through sharing results.

Maps can help you:

- **Understand commercial tobacco use in your community**

Maps can show patterns of commercial tobacco use and access in and between communities. By showing patterns and relationships, you can see areas with commercial tobacco control successes and those most affected by tobacco-related differences and disparities. Maps can also show how conditions have changed over time.

- **Identify tobacco-related disparities**

By mapping nearby areas, we are able to see how our communities differ from those around us. Mapping commercial tobacco use and access, as well as community characteristics, can reveal health disparities. Mapping provides data to better understand barriers that have challenged past efforts in communities with high commercial tobacco use prevalence.

- **Increase public understanding**

Sharing maps with community members gives them new information, helps them understand complex data, and gets them excited about your work.<sup>7</sup> Maps use symbols, colors, and legends, which can be easier to understand than numbers.

- **Visualize possible approaches**

Maps can help visualize the effect of smokefree laws, tobacco retail policies, and other commercial tobacco control strategies. You can make estimates or predictions about one area by mapping existing data from another.<sup>8</sup> This can help you plan where to implement strategies and give you a better idea of what to expect.

- **Show effectiveness**

Maps can help you show how your program's work is making a difference. Mapping your strategies can also show other organizations what you are doing, so they can invest their resources where they are most needed and avoid duplicating work.<sup>9</sup>



Maps show **patterns in commercial tobacco use, where interventions have been implemented, or how commercial tobacco use has changed over time.**

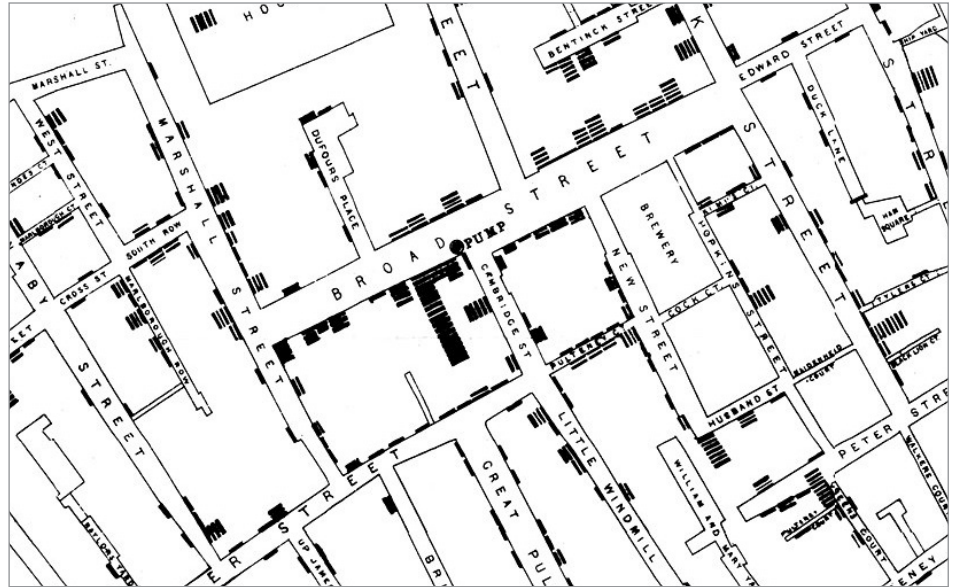


# LEARN THE BASICS

## Maps in Public Health

John Snow created the [first known public health map](#) to show London's 1854 cholera epidemic.<sup>10</sup> By mapping sick households, Snow identified a specific water pump as the source of the illness.

Snow's innovation showed that maps can help track infectious diseases, a practice public health programs still use. Maps are now also commonly used to plan and implement chronic disease programs, including commercial tobacco control strategies.



*John Snow's map of the 1854 cholera epidemic. Source: Wikipedia*

Maps were created by hand until the introduction of the first Geographic Information Systems (GIS) in the late 1960s. This new technology required cabinet-sized mainframe computers, which were not available to the public.<sup>11</sup>

Now, software and tools exist to make creating maps easier.<sup>12,13</sup> [Online trainings](#) and [university courses](#) are widely available to train public health professionals on using maps, and many states and cities have dedicated Geographic Information Systems (GIS) departments.<sup>14,15</sup>

Through the widespread popularity of the Internet, maps have evolved from static images to interactive tools. In 1999, the National Cancer Institute published an online version of its [Cancer Atlas](#), one of the first interactive public health maps.<sup>16,17</sup> Online mapping tools have also added new features such as companion data reports for a community or comparing two communities to each other.<sup>18</sup>

## What Is a Map?

In their simplest form, maps tell audiences **where things are**. Some maps display boundaries, such as zip codes, along with physical features, such as bodies of water. Others show geographic distribution of demographics or health behaviors, such as commercial tobacco use prevalence across a state.<sup>19</sup>

Many maps are made using **Geographic Information Systems (GIS)**, a computer-based tool that links data to areas on a map, such as city or zip code boundaries.<sup>19</sup> Layers of other data are added to a base map. For example, a traditional map may display the location of tobacco retailers in a city. A GIS map may then add a layer showing the cigarette smoking prevalence or data about population groups.

Maps can be **static** (fixed printed images) or **interactive**, with features that users can control. See an example of an interactive map on [page 17](#).

## WHAT MAPS SHOW

Maps show us what is happening in our communities, now and over time. What you may see on maps:

- **Trends**  
Changes over time, such as decreasing smoking prevalence or an increase in smokefree laws
- **Patterns**  
Repeating conditions and how one area compares to another, such the number of schools and tobacco retailers in different neighborhoods
- **Relationships**  
The association between sociodemographic characteristics within communities and rates of health conditions (like lung cancer)

Maps show us what is happening in our communities, through **trends, patterns, and relationships.**

### KEY RESOURCE

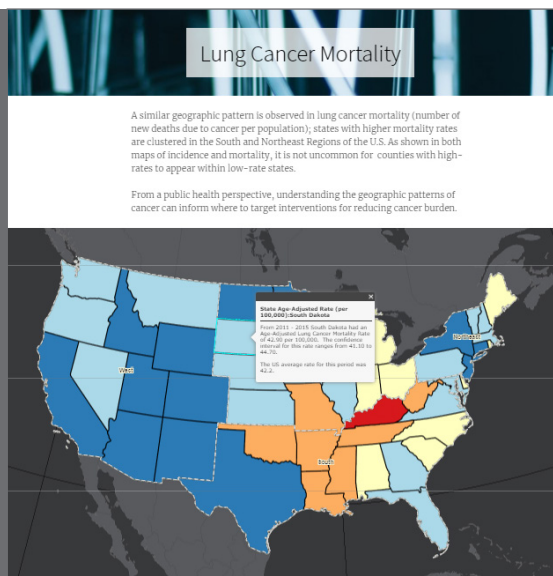
#### [GIS Dictionary \(Esri\)](#)

An online dictionary of mapping and GIS-related terms

## ENGAGING READERS WITH STORY MAPS®

Story Maps® allow users to scroll and click through a presentation of multiple maps alongside text and pictures. Story Maps® are created with Esri's Story Map® software.<sup>20</sup> While they can take extra time and resources to produce, well-crafted Story Maps® can be persuasive communication tools.<sup>21</sup>

National Cancer Institute uses its Story Map®, [Tobacco Use and Lung Cancer](#), to show rates and explain relationships between commercial tobacco use and lung cancer.<sup>22</sup> Smoke-Free Philly created its Story Map®, [By Deadly Design: The Tobacco Industry in Your Neighborhood](#), to show where commercial tobacco products are most often sold and marketed throughout Philadelphia.<sup>23</sup>










Lung cancer mortality Story Map®. Source: National Cancer Institute

## What to Map

Maps can show many kinds of commercial tobacco control information. Demographics and community characteristics can be important to show variations in commercial tobacco use. Mapping smokefree air regulations, tobacco retailers, commercial tobacco cessation services, and other activities can help your program plan and implement the recommendations in the [Best Practices—2014](#).<sup>6</sup>

### MAPPING TO SUPPORT COMMERCIAL TOBACCO CONTROL STRATEGIES

Strategy	What to Map	Example	
Commercial Tobacco Use and Disease	<ul style="list-style-type: none"> <li>• Current use of tobacco products</li> <li>• Secondhand smoke exposure</li> <li>• Rates of lung cancer and other tobacco-related disease</li> <li>• Deaths attributed to tobacco use</li> </ul>	<a href="#">Colorado</a> created an interactive map where users can view current and ever use of commercial tobacco products <sup>24</sup>	
Smokefree Air Laws	<ul style="list-style-type: none"> <li>• Adoption of state, county, city, or site-specific smokefree air laws</li> <li>• Whether laws are comprehensive</li> <li>• Historical patterns of policy adoption</li> <li>• Percent of population protected from secondhand smoke exposure</li> </ul>	<a href="#">Oregon</a> partnered with an external evaluator to create maps of smokefree ordinances and exemptions in counties across the state <sup>25</sup>	
Tobacco Retail Environment	<ul style="list-style-type: none"> <li>• Tobacco retailer locations</li> <li>• Density of tobacco retailers in an area</li> <li>• Proximity to places youth visit</li> <li>• Presence of tobacco marketing tactics</li> <li>• Whether laws are comprehensive</li> <li>• Policy adoption and compliance</li> </ul>	<a href="#">Massachusetts</a> mapped retailer density data on the community, county, and state level <sup>26</sup>	
Commercial Tobacco Cessation Interventions	<ul style="list-style-type: none"> <li>• Insurance coverage</li> <li>• Available cessation services</li> <li>• Advice to quit by healthcare providers</li> <li>• Quitline referral sources</li> <li>• Quitline use and quit attempts</li> </ul>	<a href="#">Missouri</a> showed quitline call rates per county compared to the number of people who smoke and the number of referral sources <sup>27</sup>	
Surveillance and Evaluation	<ul style="list-style-type: none"> <li>• Disparities in commercial tobacco use</li> <li>• Areas with and without strategies</li> <li>• Location and reach of program activities and cessation services</li> <li>• Changes in commercial tobacco-related attitudes, behaviors, and health outcomes</li> </ul>	<a href="#">California</a> created smoking prevalence maps to show how smoking varies both across the state and within individual counties, disproportionately impacting rural areas <sup>28</sup>	
Infrastructure, Administration, and Management	<ul style="list-style-type: none"> <li>• Program resources</li> <li>• Partners</li> <li>• Other commercial tobacco control funding</li> <li>• Progress and successes in engaging partners</li> </ul>	<a href="#">Indiana</a> included a map in its strategic plan to show counties with community-based programs <sup>29</sup>	
Reducing Tobacco-Related Disparities	<ul style="list-style-type: none"> <li>• Variation in key sociodemographic, environmental, or other risk factors (social determinants of health)</li> <li>• Disparities in commercial tobacco use</li> </ul>	<a href="#">North Carolina</a> created interactive maps showing the differences in social determinants of health and availability of resources throughout regions in the state <sup>30</sup>	





# GET READY

Taking the time to prepare for a mapping project can help **make the most of your program's resources**. Begin by working with your partners to think through the purpose of your map and what you want it to look like. This can guide the rest of your decisions. Review existing maps to see if something already exists that you can use or adapt for your needs. Before making your own maps, assess your existing technical infrastructure, staff skills, and leadership support.

## Explore Existing Maps

National organizations and federal agencies have created many excellent commercial tobacco control maps that may be useful for your project. Reviewing these maps can help you brainstorm what to display on your own maps. Other maps not directly related to commercial tobacco control can also be useful. For example, [Justice Map](#) shows race and income distribution across US cities.<sup>31</sup>

### FREE ONLINE COMMERCIAL TOBACCO CONTROL MAPS

Map (Publisher)	Information	Geographic Level	Features
<a href="#">Interactive State Tobacco Policy Map</a> (Tobacco Control Network)	Taxes, smokefree and retail laws, and preemption	State	<ul style="list-style-type: none"> <li>• Hover feature for quick overview of commercial tobacco control laws</li> <li>• Check boxes to show which states have enacted specific laws</li> </ul>
<a href="#">PLACES</a> (CDC)	Adult smoking prevalence	County, place, census tract, zip code	<ul style="list-style-type: none"> <li>• Interactive comparison of places to highlight prevention measures and health outcomes</li> <li>• Downloadable datasets</li> </ul>
<a href="#">Smokefree Lists and Maps</a> (American Nonsmokers' Rights Foundation)	Clean air laws, flavored tobacco restrictions, and e-cigarette and marijuana regulations	State, local	<ul style="list-style-type: none"> <li>• Static maps with corresponding lists and charts on smokefree regulations</li> <li>• Downloadable database of college commercial tobacco-free policies</li> </ul>
<a href="#">State Tobacco Activities Tracking and Evaluation (STATE) System</a> (CDC)	Smoking prevalence, commercial tobacco control funding, quitline use	State	<ul style="list-style-type: none"> <li>• Accompanying tables of corresponding data</li> <li>• Interactive legend to sort states by data category</li> <li>• Built-in tool to save images for your own presentations</li> </ul>
<a href="#">Tobacco Policy Viewer</a> (National Cancer Institute)	Smokefree laws for workplaces, restaurants, and bars	State, county, city	<ul style="list-style-type: none"> <li>• Animation tool to show changes in laws over time</li> <li>• Panning and zooming to focus on specific areas of the U.S. with option to view multiple layers of data</li> <li>• Downloadable state- and county-level data</li> </ul>
<a href="#">Tobacco Swamps Dashboard</a> (ASPIRE)	Disparities in concentrations of tobacco retailers	30 large U.S. cities	<ul style="list-style-type: none"> <li>• Heat map color coded to show distances to tobacco retailers</li> <li>• Geographic Information System (GIS) modeling the likely effect of tobacco retail policies in different cities</li> </ul>

## Set Up Infrastructure

Computer hardware, software, and data are the ingredients for making maps.

**Hardware** includes computers, hard drives, external storage space, and printers. Before you start a map project, assess whether your hardware has enough memory and storage space to run mapping software and store large amounts of data.<sup>32</sup>

**Software** is the computer program used to make your map and can be either an online tool or a desktop download. Some software and tools are free and available to the public, called open-source. Others may have a one-time fee or subscription. Choose the one that best fits your needs and has security features to protect against data loss if the system crashes.<sup>33</sup>

**Data** are the information used to make your map. Learn about finding data on [page 12](#).

Lower-cost options are available for programs with limited resources, including:

- Free online tools, such as [Google Maps](#) and [QGIS](#)<sup>34</sup>
- Free training courses, such as [CDC Train](#) and [online QGIS tutorials](#)<sup>35,36</sup>
- Support from Geographic Information Systems (GIS) specialists at public libraries<sup>37</sup>
- Internships with students in college GIS courses<sup>32</sup>

For example, University of North Carolina students helped to develop a map of the state's commercial tobacco cessation services. They also created a how-to manual so program staff could update the map as needed.

Before beginning to make your map, think about how you are going to share it. Will you need a website? Will your map be static or interactive? Or do you already have the channels you need? Sharing "[open data](#)" with the public creates opportunities for communities to use and apply your data in many situations.<sup>38</sup> Learn more about sharing your map on [page 18](#).

## Build Leadership Support

Helping leaders understand the benefits of mapping is important to secure staff time and resources.<sup>9</sup> Staff with mapping experience can be especially effective champions. They can explain the advantages of different maps and create sample maps to build buy-in for larger projects.<sup>9</sup>

## Train Staff

Your program may already have a GIS department, specialist, or partnership that can offer mapping knowledge and support. For example, the [Cincinnati Area Geographic Information System \(CAGIS\)](#) division



## BUDGETING FOR MAPPING

Although mapping may incur some start-up costs, maps are a smart investment. Maps reveal priority areas to help use resources efficiently.<sup>33</sup> The following questions can help you develop a mapping budget:

- Who will work on the project? What training will they need, and how much will it cost?
- How long will it take to complete the project?
- Will you need help from contractors or partners?
- Where will data come from? Does it cost to use the data?
- Will new data need to be collected?
- What mapping tools and software will you need?
- Are existing computers capable of running mapping software?

helps city and county agencies integrate data and technology to create maps.<sup>39</sup> Online user groups are also good places to share knowledge and connect with others doing similar work.

No matter who creates your maps, developing GIS experience among your own staff is vital to keep maps up to date.<sup>9,40</sup> Having skilled staff on your team is especially important if other departments have limited time and resources to support your mapping project.<sup>9</sup>

Creating maps typically requires more staff time and skill than making simple graphs or tables.<sup>9</sup> Staff may need training in:

- Finding and working with datasets
- Collecting new data to use in maps
- Using mapping software
- Designing effective maps that do not unintentionally mask disparities
- Program evaluation and quality improvement to take action based on what the maps reveal, including distinguishing differences from disparities

Depending on your staff's skill level, a user's manual may be adequate to use the basic features of many tools. Tutorials, help from experienced users, or training courses are often needed to use more complex desktop-based software.<sup>32</sup> **Free and low-cost online GIS training** is available for both beginners and advanced users.

Plan effective training by following these **training best practices**:

- Include data analysts and epidemiologists on your mapping team<sup>13</sup>
- Choose training topics and formats that meet your staff's needs<sup>41</sup>
- Have someone with GIS experience demonstrate the basics<sup>32</sup>
- Create opportunities to develop and practice new mapping skills<sup>9</sup>
- Connect staff to peer groups so they can connect with other GIS users<sup>42</sup>



**Staff in other departments** may have experience with mapping and be able to offer technical help.

## KEY RESOURCES

### [Building GIS Capacity for Chronic Disease Surveillance \(CDC\)](#)

A training program health departments can participate in to learn about GIS and enhance skills

### [Chronic Disease GIS Exchange \(CDC\)](#)

An online forum for public health professionals to share GIS tips

### [Esri Academy \(Esri\)](#)

Fee-based and free training on a range of GIS topics, including data management, making maps, and visualization

### [GIS Learning \(GIS Lounge\)](#)

GIS learning resources, including free courses, online tutorials, and downloadable manuals

### [GIS Training \(CDC and Children's Environmental Health Initiative\)](#)

Free web-based mapping tutorials, ranging from introductory to advanced

### [GIS User Groups \(GIS Lounge\)](#)

GIS user groups listed by state

### [QGIS Training Manual \(QGIS Project\)](#)

Continuously updated training manual for QGIS open-source software, including lessons, exercises, and answer keys



# TAKE ACTION

These six steps can help you design user-friendly and impactful commercial tobacco control maps:

- 1. DECIDE WHAT TO MAP** – Explore commercial tobacco-related issues and prevention resources in your community and identify your audience.
- 2. GET DATA** – Find existing data for your map or collect data about your community.
- 3. CHOOSE SOFTWARE** – Pick the right software to make your map based on your purpose for the map and available resources.
- 4. DESIGN YOUR MAP** – Choose a map design and add design elements to create a clear and understandable map.
- 5. TEST YOUR MAP** – Ask a sample of your audience to review the map and make helpful improvements based on their feedback.
- 6. USE YOUR MAP** – Use your map to make decisions and communicate with your audience.

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## Step 1 ▶ Decide What to Map

To start a mapping project, you and your partners will first decide **what you want to show, where, and to whom**. These choices will guide the rest of your map development, from choosing data to designing the look and feel.

### CHOOSE A MAP PURPOSE

Work with your partners to determine their priorities and questions, what data could answer those questions, and whether mapping the data could reveal new insights.<sup>43,44</sup> Your partners may want to know:<sup>32</sup>

- What is the state of commercial tobacco control in my community?
- What areas have comprehensive model strategies? Where have only partial strategies been implemented?
- Where are commercial tobacco control strategies most critical?
- What changes have occurred in commercial tobacco control strategies, commercial tobacco use, or health outcomes?
- What changes in other characteristics have occurred in my community?
- What has happened when commercial tobacco control strategies have been implemented at the local, state, or national level?
- What could happen if we implemented commercial tobacco control strategies?

Whether your map is for program staff or external partners, involve them at all steps, including in deciding what to map and creating the map. Learn more about partners through interviews, surveys, or focus groups.<sup>45</sup>

**First, decide** what you want to show, where, and to whom.

**Involve members** of your intended audience in the mapping process.

## DEFINE YOUR AUDIENCE

Identifying your audience means **deciding who you think would most benefit** from your map.

Maps can be shared with many audiences:

- Public health professionals
- Decision makers
- Partners
- Researchers
- Community members



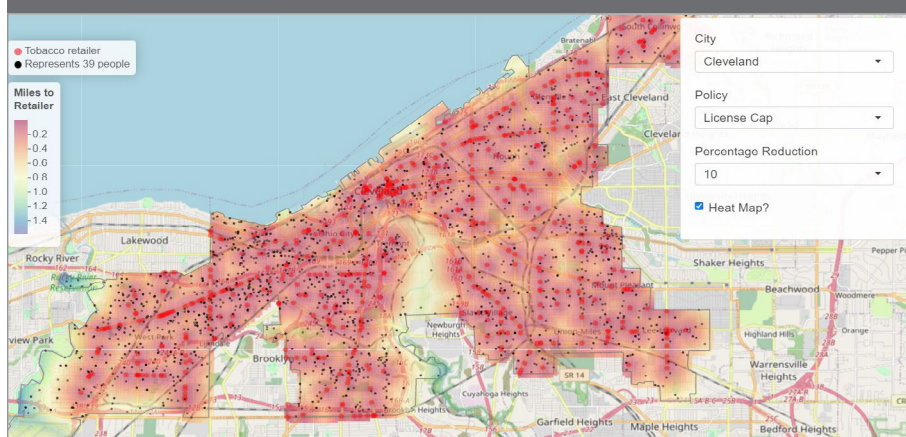
**Modeling** uses existing data to estimate an unknown outcome by simulating real-world conditions.

## PREDICTING OUTCOMES WITH MAP MODELS

Maps can show us more than how things are. They can also show us how things could be. **Modeling** uses existing data to estimate an unknown outcome by simulating real-world conditions.<sup>45</sup> For example, researchers modeled the potential effects of different outdoor commercial tobacco advertising restrictions in St. Louis and New York City.<sup>47</sup>

Modeling can even be used to predict the behavior of individuals. Agent-based modeling (ABM) examines the way people (agents) interact with their environment. This kind of modeling requires advanced technical skill, but ABM tools are available that allow programs to explore possible policy scenarios.

For example, the ASPIRE Center's Tobacco Town project is creating models for select cities across the U.S.<sup>48</sup> Practitioners in these cities will be able to explore the impact of different retail policies on commercial tobacco use in their communities.



*Tobacco Swamps interactive dashboard. Source: ASPIRE Center's Tobacco Town project, funded by the National Cancer Institute*

Thinking through how to make your map easy to use and accessible for your audience will help you decide what to map and how to map it. Consider the following questions about your audience:

- What does the audience already know about the data and area you plan to map?
- What are the audience's goals and interests?
- How can the map help support these goals?
- What format would be most useful for the audience (PDF, web, mobile)?
- Would an accompanying downloadable dataset be helpful?
- Does the audience need any special accommodations to help make sense of complex information (such as pictures, large print text, or high contrast colors)?

## SELECT THE AREA AND SCALE

You may decide to map a larger area, such as the U.S., or a smaller area, such as a community or neighborhood. The data available for your map may determine what scale you use.

**Mapping a larger area** can help show how your community compares to others on key commercial tobacco control indicators. A map showing a larger area such as an entire country or continent will show less detail.<sup>32</sup> Since large-scale maps show less detail, they can hide important information, like tobacco-related disparities and related characteristics.<sup>49</sup>

**Mapping a smaller area**, such as a neighborhood, can help show the local landscape. The map can appear zoomed in and show greater detail.<sup>7</sup> Including more detail helps show disparities within your community and inform where to focus strategies.<sup>33</sup>

## KEY RESOURCES

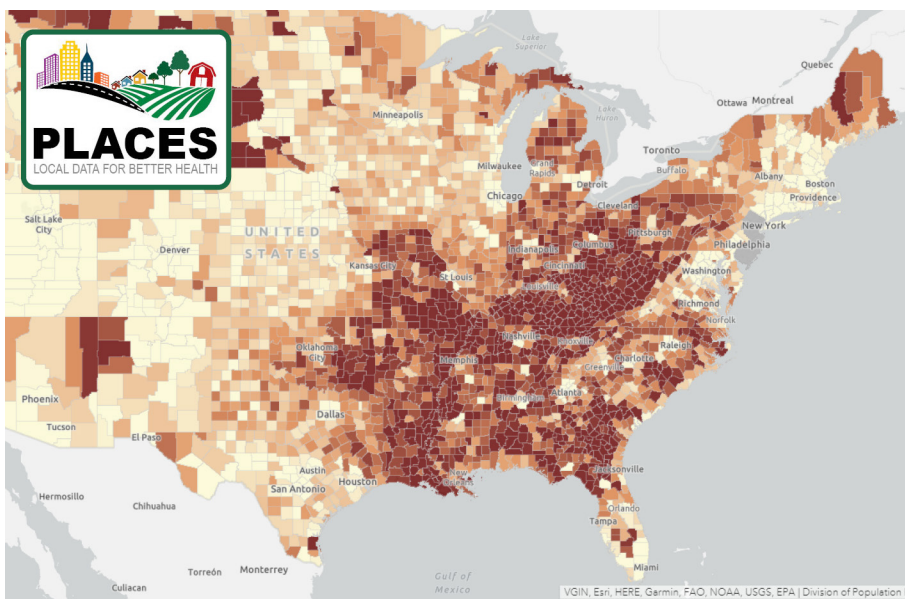
### [Best Practices User Guide: Health Communications in Tobacco Prevention and Control \(CDC\)](#)

How to develop effective health communications, including researching the audience

### [Geographic Information Systems: Tools for Community Mapping \(Community Tool Box\)](#)

GIS basics and mapping guidance, such as how to decide your map purpose and audience

**Different scales** highlight different relationships on your maps.



Screenshot of interactive map of county-level smoking prevalence. Source: CDC Places

## Step 2> Find Data

Maps use two types of data. **Geospatial data** define the physical features and political boundaries of an area. These data come in three geometries: point, line, and polygon. All three are important for making maps.<sup>50</sup>

- Point data refers to single points on a map, such as addresses.
- Line data are often used for streets or other lines on a map, such as sewer lines.
- Polygon data represent geographical boundaries, such as zip codes or political districts.

Social, economic, and other population data are often referred to as **attribute data**. For example, this includes smoking prevalence, types of policies, and tobacco retailer locations. These data are added as layers on the base map. They are most helpful when already broken down by a geographic level like city, county, or ZIP code.

### DOWNLOAD DATA

Geospatial data can be downloaded as [shapefiles](#) and used to create the base map.<sup>51</sup> Census tracts and block groups are common shapefiles from [The US Census Bureau](#), [Homeland Infrastructure Foundation Level Data](#), and the [National Historical Geographic Information System](#).<sup>52,53</sup> Attribute data can be found either as tables or shapefiles.

### THE 5WS TO EVALUATE DATA:

#### WHO

Who made it?

#### WHAT

What does it represent?  
Does it match what you need?

#### WHERE

Where does it come from?  
Are sources cited and reputable?

#### WHEN

When was it created?

#### WHY

Why was it made?  
What is the purpose of the data?

*Adapted from Zhang and Huang, 2013<sup>54</sup>*

## Where to Find Mapping Data



### Cessation

- [CDC's STATE System](#)
- [NIH's Tobacco Use Supplement to the Current Population Survey](#)



### Demographics and Determinants of Health

- [US Census Bureau](#)
- Local health departments
- [CDC/ATSDR's Social Vulnerability Index](#)



### Funding

- [ALA's State Legislated Actions on Tobacco Issues \(SLATI\)](#)



### Policies and Enforcement

- [FDA Compliance Check Data](#)
- [Temple's LawAtlas](#)



### Prevalence

- [CDC's Behavioral Risk Factors Data Portal](#)
- [America's Health Rankings](#)
- [NCI's Tobacco Use Supplement to the Current Population Survey](#)
- [CDC's STATE System](#)
- [CDC's National Youth Tobacco Survey](#)



### Smokefree Policies

- [NCI's Tobacco Policy Viewer](#)
- [CDC's STATE System](#)
- [ANR Foundation's Smokefree Lists and Maps](#)
- [ALA's State Legislated Actions on Tobacco Issues \(SLATI\)](#)



### Tobacco Retailers

- [CDC's STATE System](#)
- [Reference USA](#)
- Local retailer lists

Data not available as shapefiles will need to be linked to a geographic coordinate system. This can be done by **“joining”** the data as an attribute table to an existing shapefile.<sup>55</sup> Another way is through **geo-referencing**, or geo-coding, which uses street addresses to get coordinates.<sup>56</sup> Online tools can help you do this, such as Texas A&M’s **Geocoding Services**.<sup>57</sup>

Good data sources for mapping have consistent data for the **geographic level** and **time frame** you are interested in.<sup>58</sup> Public data sources can include local health departments, healthcare systems, and governments. Consult your state or city GIS department for available data sources. For example, **Missouri’s Spatial Data Information Service** gives open access to geospatial data on a variety of topics.<sup>59</sup> Universities often provide geospatial data. For example, the University of Wisconsin created **GeoData@Wisconsin**, an online portal with state data, imagery, and maps.<sup>60</sup>

If you cannot find exactly what you need, try looking for the data on a different geographic level. For example, if you can’t find zip code data, try using census tract data. Or decide if using a different year would still result in relevant data.

## KNOW THE LIMITATIONS OF YOUR DATA

When data is limited for an area, **omitting** data from that area can avoid large statistical errors that may mislead users.<sup>61</sup> If you are missing a lot of data, you may want to **aggregate** data across larger areas, like state-level instead of county-level, or combine data from several years. These changes can help make up for omitted data, but the map may not show important local-level differences or recent changes.

## COLLECT YOUR OWN DATA

Some data may not be available for your community, like information about local tobacco retailers, health systems, or public opinion. **Surveys** and **store observations** are two common ways to collect these data. As you plan your data collection efforts, think about:

- Whether staff or volunteers will collect the data
- What training they will need
- What safety measures will be important as they go out into the community

If you plan to use tobacco retail data, maintaining an updated list of addresses for tobacco and e-cigarette retailers makes it easier to create maps.<sup>62</sup>

## KEY RESOURCES

### [Collecting and Analyzing Data \(Community Tool Box\)](#)

Guidance on collecting your own data

### [Geospatial Data Resources \(CDC\)](#)

Common GIS data sources for health mapping

### [Geocodio](#)

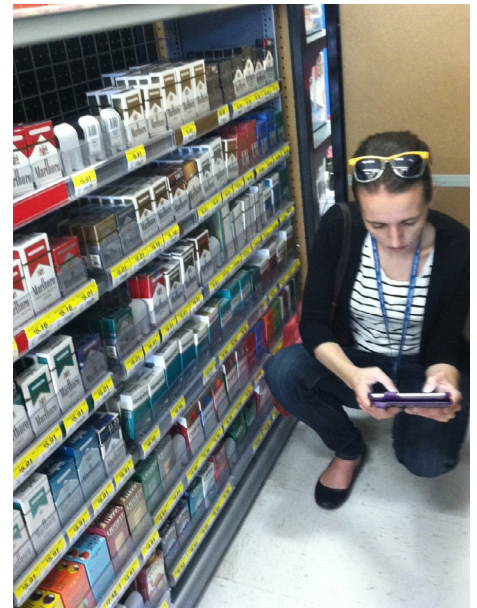
Online tool to geocode street addresses to coordinates from a spreadsheet

### [STARS, vSTARS, fSTARS \(Counter Tobacco\)](#)

Store assessment tools to collect information about tobacco retailers, vape shops, and retailers who sell flavored tobacco

### [Resources to Format Data for Mapping:](#)

- [File Formats for GIS \(University of Delaware\)](#)
- [Formatting a table in Excel for ArcGIS® \(ArcGIS\)](#)



*Inga Suneson, an AmeriCorps VISTA service member with Multnomah County Health Department collects data for a tobacco retail assessment. Source: Multnomah County Health Department, Oregon*



## Step 3 > Choose Software

Many **software tools** are available to make maps. Some create simple maps, while others can make complex maps with many layers of data. Some only allow maps to be printed or copied as an image; others can embed maps into websites. Software may be available free online or have a fee to download and use. Your GIS department may have a preferred software.

Some **coding languages** work with software to create maps. For example, Python makes maps through [Plotly](#), and R makes maps through [Leaflet](#). If your program staff has coding knowledge, they may be able to use these tools to make maps. Others, like those listed in the table below, need no knowledge of coding.

You may be able to find an online tool specifically designed to create the map you need. For example, [Florida](#) used Counter Tool's Store Mapper to map retailers throughout the state.<sup>63</sup> Important considerations when choosing software are **cost**, **how you will use your map**, and the **skill level** needed to use the software.



### MAPPING SOFTWARE

Name (Creator)	Cost	Skill Level	Good For	Features
<a href="#">Epi Map</a> (CDC)	Free	Beginner	<ul style="list-style-type: none"> <li>Creating interactive maps to create multiple views of the same data</li> <li>Identifying clusters of data</li> </ul>	<ul style="list-style-type: none"> <li>Upload data or choose from select data available</li> <li>Turn a street address into geographic coordinates</li> <li>Part of CDC's EpiInfo software tools with <a href="#">user guide</a><sup>64</sup></li> </ul>
<a href="#">Google Earth</a> (Google)	Free	Beginner	<ul style="list-style-type: none"> <li>Marking locations with symbols</li> </ul>	<ul style="list-style-type: none"> <li>Upload layers of data</li> <li>Embed map to a website or share with a unique link</li> </ul>
<a href="#">Tableau Public</a> (Tableau)	Free	Beginner	<ul style="list-style-type: none"> <li>Creating interactive maps</li> <li>Showing relationships between data</li> <li>Sharing online</li> </ul>	<ul style="list-style-type: none"> <li>Create interactive data dashboards</li> <li>Make graphics to accompany maps</li> <li>Watch <a href="#">training videos</a><sup>65</sup></li> </ul>
<a href="#">GIS Cloud</a> (GIS Cloud)	Varies	Beginner	<ul style="list-style-type: none"> <li>Creating maps with a team</li> </ul>	<ul style="list-style-type: none"> <li>Collect data through mobile devices</li> <li>Publish maps compatible with other GIS software</li> <li>Online certification program available</li> </ul>
<a href="#">QGIS</a> (The QGIS Project)	Free	Beginner to Intermediate	<ul style="list-style-type: none"> <li>Analyzing data</li> <li>Visualizing relationships</li> <li>Making basic and advanced maps</li> </ul>	<ul style="list-style-type: none"> <li>Compatible with advanced <a href="#">GRASS GIS</a> extensions<sup>66</sup></li> <li>Learn from <a href="#">a training manual</a><sup>67</sup></li> </ul>
<a href="#">MapInfo Pro</a> (Pitney Bowes)	Varies	Intermediate	<ul style="list-style-type: none"> <li>Analyzing data</li> <li>Creating interactive maps</li> </ul>	<ul style="list-style-type: none"> <li>Turn a street address into geographic coordinates</li> <li>Read and create file formats compatible with other software</li> <li>Access <a href="#">MapInfo Community</a> for peer support<sup>68</sup></li> </ul>
<a href="#">GeoDa</a> (ASU GeoDa Data Center)	Free	Intermediate to Advanced	<ul style="list-style-type: none"> <li>Statistically identifying relationships</li> <li>Identifying clusters of data</li> </ul>	<ul style="list-style-type: none"> <li>Link maps and charts to model data</li> <li>Access <a href="#">mailing list and FAQ answers</a> for support<sup>69</sup></li> </ul>
<a href="#">ArcGIS</a> (Esri)	Varies	Intermediate to Advanced	<ul style="list-style-type: none"> <li>Making basic and advanced maps</li> <li>Analyzing data with statistical tools</li> <li>Highlighting a specific relationship</li> </ul>	<ul style="list-style-type: none"> <li>Add data from Living Atlas Library</li> <li>Turn a street address into geographic coordinates</li> <li>Watch <a href="#">tutorials</a><sup>70</sup></li> </ul>
<a href="#">Power BI</a> (Microsoft)	Varies	Intermediate to Advanced	<ul style="list-style-type: none"> <li>Creating interactive maps</li> <li>Creating maps with a team</li> <li>Analyzing data with statistical tools</li> </ul>	<ul style="list-style-type: none"> <li>Analyze data with accompanying dashboard</li> <li>Instantly geocode data</li> <li>Link data to automatically update maps</li> </ul>

## Step 4 Design Your Map

A well-designed map allows a user to quickly interpret the map without turning to other resources.<sup>61</sup> To design clear, concise maps:

- Select a map type
- Choose the correct map projection
- Add elements to aid understanding
- Follow best practices for data visualization

### SELECT A MAP TYPE

Choosing the right map type depends on what kind of information you and your partners want to display:

- **Choropleth** maps use shading and color to show polygon data within set boundaries, such as policy status and trends. Choropleth maps are good for showing rates.<sup>19</sup>
- **Heat** maps show continuous data that is not limited by geographic boundaries like counties or zip codes. Heat maps are good for showing density.<sup>61</sup>
- **Symbol** maps use symbols that vary in shape and size to show magnitude, quantity, or categories of point data.<sup>19</sup> For example, larger symbols can show areas with more tobacco retailers. Different symbols can show categories, like cities with partial or comprehensive smokefree laws.

### CHOOSE A PROJECTION

**Projections** are coordinate systems that define locations of existing places.<sup>71</sup>

When using complex tools, such as Geographic Information Systems (GIS), choose consistent and correct projections to make sure your map is visually correct. If you select the wrong projection for your data, your image may appear distorted. For example, your state can appear much wider and shorter than it really is.

### ADD ELEMENTS TO AID UNDERSTANDING

Most maps have the same basic parts. These elements give clues that help the audience understand what the map is trying to say.<sup>19,61</sup> You can aid understanding by adding the following elements to your maps:

- **Title** that describes the purpose of the map
- **Legend** to explain symbols used in the map
- **Scale bars** to show size and distance
- **North arrow** to show orientation
- **Source information** about who created the map, when it was created, and when the data was collected, and where the data came from

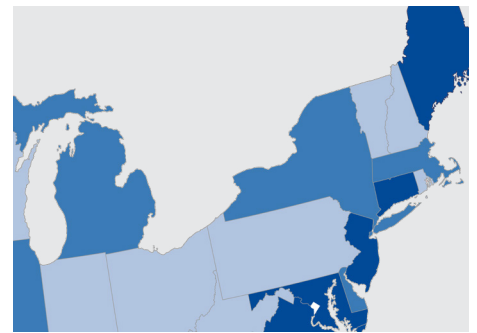
### KEY RESOURCES

#### [Cartographic Guidelines for Public Health \(CDC\)](#)

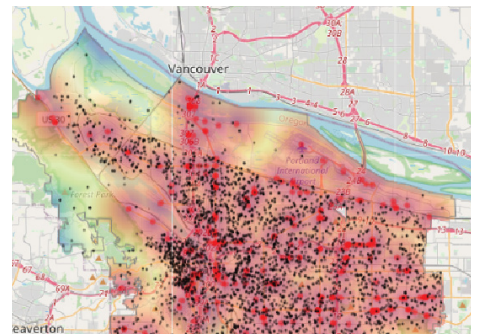
Best practices for designing health maps

#### [Color Brewer](#)

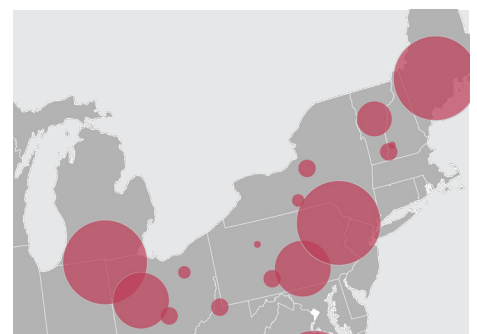
An online tool to help map designers check color schemes for readability



Choropleth map



Heat map



Symbol map

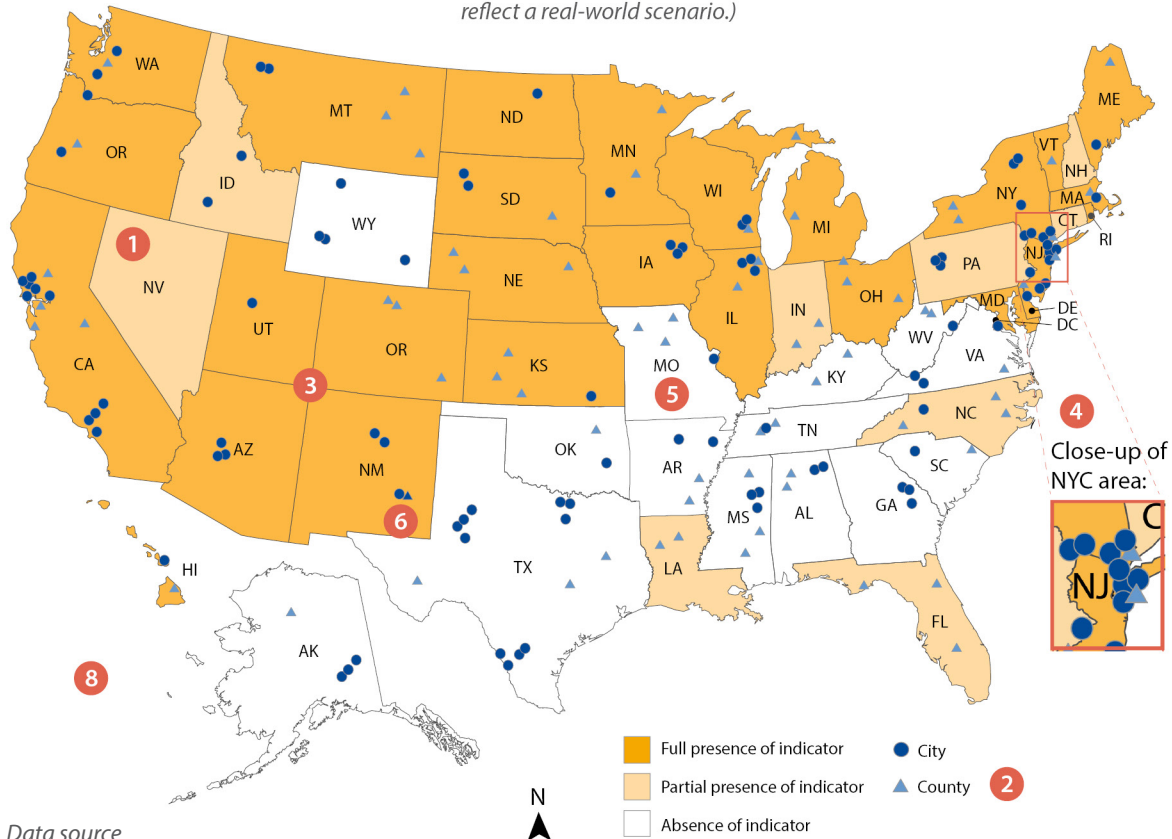
## USE DATA VIZ BEST PRACTICES

Best practices for using symbols, colors, patterns, and text help reduce clutter and emphasize important features. Include **seven (or fewer) variables** to keep your map clean and understandable. Use the following guidelines to design user-friendly, understandable maps:<sup>19</sup>

- 1 **Color:** Use **lighter shades** for lower numbers and **darker shades** for higher numbers. Always use highly saturated colors instead of transparent colors. Avoid color combinations that are difficult for colorblind audiences to see and use intuitive color schemes. For example, use green to show 'good' trends or successes.
- 2 **Font:** Stick to **one or two** fonts. Label similar features with the same font. Use variations of the font to show differences. Use larger type and more prominent fonts for the most important information.
- 3 **Lines:** Use a fine line to **border** your map and separate geographical areas. Be sure that the lines do not block text or other map elements.
- 4 **Multiples:** Set maps at the **same size and scale**. Present maps in a logical order. Use maps or parts of maps with different scales to highlight sections of larger maps.
- 5 **Patterns:** Use solid white or gray to show missing or zero data. Use hatch patterns for data that are too few to be statistically counted. **Limit use** of patterns to keep your map from looking cluttered.
- 6 **Symbols:** Use different symbols to display different **categories**. Use larger or smaller symbols to show quantities. Use standard, recognizable symbols for common places such as a hospital or school.
- 7 **Text:** Label only what is **necessary** to understand your map. Pay attention to how text looks on background colors and lines to make sure it is easy to read.
- 8 **White Space:** Include white space so your reader can better **understand** what your map is saying without being overwhelmed.

### Data Viz Best Practices Demonstration Map (2021) 7

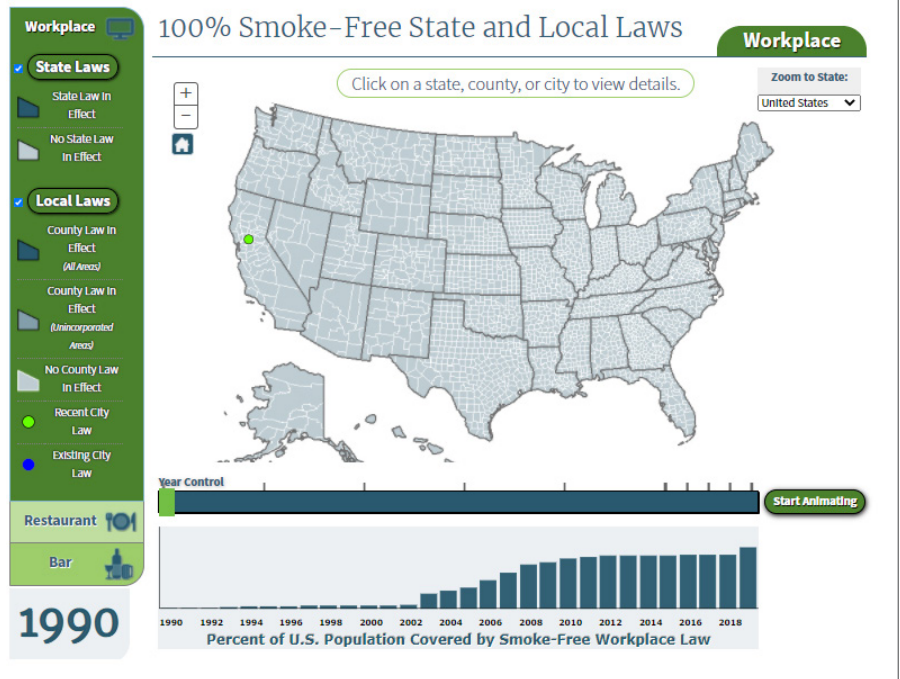
*(Data points and shading are for example purposes only and do not reflect a real-world scenario.)*



## INTERACTIVE MAPS

On static maps, the mapmakers choose which data to show users.<sup>61</sup> **Interactive maps** let users choose data or focus on specific locations. Common design features of interactive maps include:<sup>33</sup>

- **“Mouse-over”** functions that show details about a geographic area
- **Ability to zoom** into the map to focus on a specific location
- **Panning** to explore detailed information about different areas
- **Animation** to show changes over time (may be automatic or activated by the user, such as check-boxes to view different layers of data)



Interactive map of smokefree state and local laws. Source: National Cancer Institute's Tobacco Policy Viewer

## Step 5 ▶ Test Your Map

Test your map with potential audiences and partners to figure out how easy it is to understand. Use their feedback to improve your map's usability. Center your testing around these three questions:

- **Do audiences understand the map?**  
Ask testers to review the map and explain it back to you.
- **Can audiences apply the map to their work?**  
Ask testers to use the map as they would in their work. Ask them how they would use the map to make decisions. Have them describe what is easy to use, what is confusing, and what could be improved.
- **Are interactive elements helpful?**  
Have testers try out interactive elements to make sure they work and are easy to use.<sup>72</sup> Have testers try out the map on a computer and on smartphones.



## Step 6> Use Your Map

Once your map is complete, you can use it to build and maintain support for your work. Maps can serve as a basis for decision making and collaboration, bringing resources to the areas that need them most.<sup>73,74</sup> Maps can be more effective than graphs and tables in clearly communicating information.<sup>74</sup> Maps are helpful for showing either the need for your work or the results of it in products like:

- Funding applications<sup>9</sup>
- Reports for decision making and allocating resources<sup>75</sup>
- Community assessments<sup>74</sup>
- Educational materials for the community or decision makers<sup>74</sup>

Consider how your audience will use your map—will they view it **on a screen or in print**? A map designed for a poster presentation may not be readable on a mobile phone. Print-friendly versions can help users share online interactive maps.<sup>19</sup>

When sharing maps, choose communications channels that your audience already uses. Use **more than one channel**, such as websites, social media, and e-mail.

Consider including supporting graphs, tables, or text to help share your message, like the [New York City Housing Authority webpage](#) about smokefree housing.<sup>76</sup> You can also accompany your map with downloadable data or a data dashboard.

Make your map **accessible** to people with disabilities.<sup>77</sup> Features like high color contrast and alternative text descriptions ensure that anyone can read your map. Accessibility may be required for maps supported by federal funding.

A map can lose its effectiveness as new information becomes available. **Regularly update maps**, ideally once a year. Most public health surveillance systems collect data annually.<sup>78</sup> You may be able to link your map to online sources so that it is automatically updated when new data is available.

Ask audiences how they use your map to make decisions, like allocating resources. This can help you determine if your map is meeting its intended purpose.

### KEY RESOURCES

#### [Best Practices User Guide: Health Communications in Tobacco Prevention and Control \(CDC\)](#)

How to develop effective health communications, including pros and cons of communications channels

#### [United States Access Board](#)

Guidelines and standards for creating accessible documents

#### [What is Usability Testing? \(Tmap\)](#)

How to conduct usability testing, questions to ask, and downloadable assessment forms



# EXPLORE COMMUNITY EXAMPLES

## Montana

Knowing that exposure to tobacco retail marketing causes youth to start smoking, the Montana Tobacco Use Prevention Program wanted to take action to reduce youth tobacco marketing.<sup>79</sup> After seeing retailer maps made by other states, the program decided to create a visual, online tool to educate decision makers called the [Tobacco Retailer Mapper](#) in 2014.<sup>80</sup>

The program used ArcGIS® to create the Mapper as an online Story Map®.<sup>20</sup> The Mapper includes three city- and county-level maps:

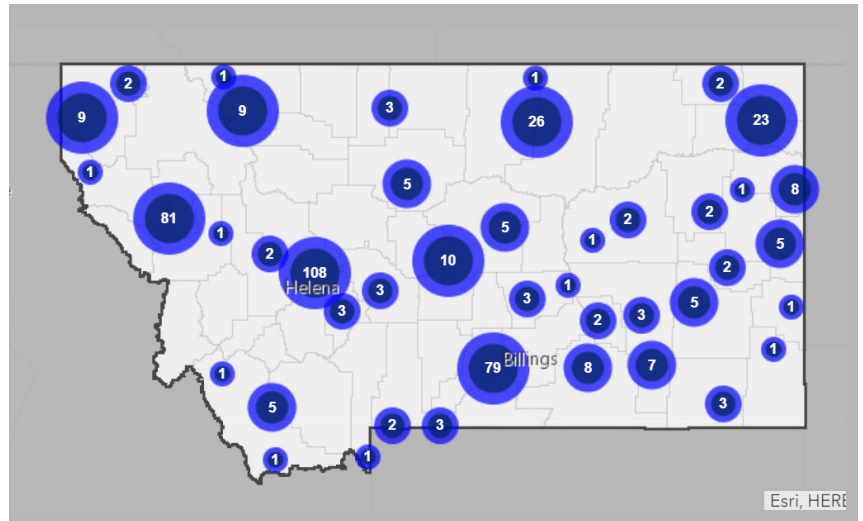
- A **youth access map** that uses color-coded symbols to show tobacco retailers near schools
- A **retailer density map** that uses symbols of different sizes to show clusters of retailers within a 10-minute walk from a school
- A **retailer compliance map** with color-coded dots of different sizes indicating the number of times a minor was able to purchase commercial tobacco during retailer compliance checks

The Mapper also lets users make data reports for cities, counties, tribal reservations, or state legislative districts. “We thought it was a really easy way to get information across. It was very different from the traditional public health websites,” says Lisa Richidt, lead epidemiologist for the Mapper.

The program included accurate, local-level data to make sure the Mapper was useful for community partners. “**The more local-level data you can include, the better,**” says program manager Nicole Aune. Staff worked with partners to gather data from community assessments and existing sources. Next, they linked the data to latitude and longitude coordinates so it could be used for mapping.

The team also wanted the Mapper to be relevant to county-level partners. Search bars and clickable icons help users find information about their community. The program regularly promotes the Mapper to county partners and has even trained local youth to use the Mapper and educate their own local decision makers.

The program hired local consultants to create the Mapper but maintain it with internal staff. Program staff update the data every two years. Richidt suggests that programs assign a staff member to GIS projects. Dedicated staff is especially important since the commercial tobacco environment changes quickly.



Screenshot from Montana Tobacco Retailer Mapper showing retailers near schools

“ We thought the Mapper was a **really easy way to get information across**. It was very different from the traditional public health websites.”

— Lisa Richidt

## North Carolina

North Carolina made restaurants and bars smokefree in 2010. The law also allowed local governments to further restrict smoking in public spaces and on government property.

The North Carolina Tobacco Prevention and Control Branch wanted to track these local policy efforts. They asked the State Center for Health Statistics to develop maps showing city and county smokefree and tobacco-free policies across the state.

The maps are featured on North Carolina's [Department of Health and Human Services website](#) and include:<sup>81</sup>

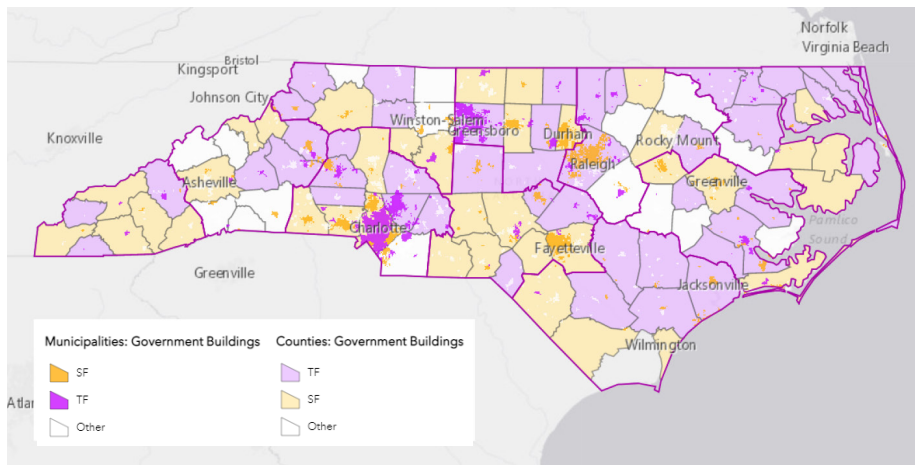
- Four **static maps** showing smokefree regulations on government grounds, government buildings, parks, and enclosed public spaces
- An **interactive map** that allows users to select layers and view policies by clicking areas
- Two **data dashboards** displaying the regulations in tables by county and municipality

The program involved the North Carolina Association of Local Health Directors early in the mapping process. The local health directors liked the idea of being able to see other counties' progress. They were especially interested in counties similar to their own. Sally Herndon is head of the Tobacco Prevention and Control Branch. She says, "The maps not only help our local health directors build support for evidence-based policies, but are also a useful tool for advocates, physicians, and others involved in this work."

The program also works with 10 state-funded regional managers in county health departments. They share data to **update the maps through quarterly reports**. This data helps the program feel confident that they are getting a complete picture of North Carolina's policy landscape.

New team members are trained how to use the reporting system, review policies, and manage data. Entering policies into the database can be challenging because local policies vary widely in language and structure. If they have questions, they consult an attorney.

The maps **only include 100 percent smokefree or 100 percent tobacco-free policies**. The program believes this promotes evidence-based policy and helps communicate the state's commercial tobacco control goals.



Screenshot from North Carolina's interactive map of smokefree and tobacco-free local government policies

“The maps not only help our **local health directors** build support for evidence-based policies, but are also a useful tool for **advocates, physicians, and others** involved in this work.”

— Sally Herndon



# REFERENCES

- 1 Tobacco. The Community Guide. Accessed May 20, 2020. <https://www.thecommunityguide.org/topic/tobacco>.
- 2 US Department of Health and Human Services. *The health consequences of smoking—50 years of progress: a report of the Surgeon General*. Published 2014. Accessed September 14, 2018. <https://pubmed.ncbi.nlm.nih.gov/24455788/>.
- 3 Farrelly M, Chaloupka F, Berg C, et al. Taking stock of tobacco control program and policy science and impact in the United States. *Journal of Addictive Behaviors and Therapy*. 2017;1(2:8). <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6124688>
- 4 Holmes C, King B, Babb S. Stuck in neutral: stalled progress in statewide comprehensive smoke-free laws and cigarette excise taxes, United States, 2000–2014. *Preventing Chronic Disease*. 2016;13:150409. doi: [10.5888/pcd13.150409](https://doi.org/10.5888/pcd13.150409).
- 5 Garrett B, Dube S, Babb S, McAfee T. Addressing the social determinants of health to reduce tobacco-related disparities. *Nicotine & Tobacco Research*. 2015;17(8):892-897. doi: [10.1093/ntr/ntu266](https://doi.org/10.1093/ntr/ntu266).
- 6 Centers for Disease Control and Prevention. *Best Practices For Comprehensive Tobacco Control Programs—2014*. Published 2014. Accessed September 14, 2018. [https://www.cdc.gov/tobacco/stateandcommunity/best\\_practices/index.htm](https://www.cdc.gov/tobacco/stateandcommunity/best_practices/index.htm).
- 7 Croner C. Public health, GIS, and the Internet. *Annual Review of Public Health*. 2003;24(1):57-82. doi: [10.1146/annurev.publhealth.24.012902.140835](https://doi.org/10.1146/annurev.publhealth.24.012902.140835).
- 8 Reisner J. GIS modeling. February 8, 2011; Rowan University. Accessed April 22, 2020. <https://www.slideshare.net/johnreiser/gis-modeling>.
- 9 Brissette I, Casper M, Huston S, et al. Application of geographic information systems to address chronic disease priorities: experiences in state and local health departments. *Preventing Chronic Disease*. 2019;16:180674. doi: [10.5888/pcd16.180674](https://doi.org/10.5888/pcd16.180674).
- 10 Maps of the 1854 Broad Street Pump outbreak. University of California Los Angeles. Accessed February 4, 2022. <https://www.ph.ucla.edu/epi/snow/mapsbroadstreet.html>.
- 11 Mullner R, Chung K, Croke K, Mensah E. Introduction: geographic information systems in public health and medicine. *Journal of Medical Systems*. 2004;28(3):215-221. doi: [10.1023/B:JOMS.0000032972.29060.dd](https://doi.org/10.1023/B:JOMS.0000032972.29060.dd).
- 12 Esri. ArcGIS. Accessed June 16, 2020. [www.arcgis.com](http://www.arcgis.com).
- 13 Maptitude. Caliper. Accessed May 8, 2020. <https://www.caliper.com/maptovu.htm>.
- 14 Esri Academy. Esri. Accessed May 8, 2020. <https://www.esri.com/training/>.
- 15 University of California, Davis. Fundamentals of GIS. Coursera. Published 2020. Accessed May 8, 2020. <https://www.coursera.org/learn/gis>.
- 16 Pickle L. A history and critique of U.S. mortality atlases. *Spatial and Spatio-temporal Epidemiology*. 2009;1(1). doi: [10.1016/j.sste.2009.07.004](https://doi.org/10.1016/j.sste.2009.07.004).
- 17 The Cancer Atlas. Accessed February 4, 2022. <http://canceratlas.cancer.org/9WS>.
- 18 PLACES: Local Data for Better Health. Centers for Disease Control and Prevention. Published December 8, 2020. Accessed January 7, 2021. <https://www.cdc.gov/500cities/>.
- 19 Centers for Disease Control and Prevention. Cartographic guidelines for public health. Published August 2012. Accessed February 19, 2020. [https://www.cdc.gov/dhdsdp/maps/gisx/resources/cartographic\\_guidelines.pdf](https://www.cdc.gov/dhdsdp/maps/gisx/resources/cartographic_guidelines.pdf).
- 20 ArcGIS StoryMaps. Esri. Accessed March 24, 2020. <https://www.esri.com/en-us/arcgis/products/arcgis-storymaps/overview>.
- 21 Getting the most from animated maps. ArcGIS StoryMaps. Accessed March 24, 2020. <https://storymaps.arcgis.com/stories/0771bda76965451c9df8dd2d0759f9fd>.
- 22 National Cancer Institute. Tobacco use & lung cancer. Geographic Information Systems and Science for Cancer Control. Accessed December 10, 2019. <https://gis.cancer.gov/mapstory/tobacco/index.html>.
- 23 By deadly design: the tobacco industry in your neighborhood. Smoke-Free Philly. Accessed December 10, 2019. <http://phl.maps.arcgis.com/apps/MapJournal/index.html?appid=2f139f9db50a47c99bd5c13bfb4a9d2b>.
- 24 VISION: Visual information system for identifying opportunities and needs. Colorado Department of Public Health and Environment. Published 2019. Accessed March 4, 2020. <https://cdphe.colorado.gov/vision-visual-information-system-for-identifying-opportunities-and-needs>.
- 25 Rede Group. Indoor clean air act expansion evaluation. Oregon Health Authority. Published 2018. Accessed February 4, 2022. <https://static1.squarespace.com/static/5137d873e4b08ef26b549821/t/5b2a6ebc70a6adb53dbd8b02/1529507523753/ICAAEE+Map+Series.pdf>.
- 26 Department of Public Health analytics. Massachusetts Department of Public Health. Accessed February 4, 2022. [https://dphanalytics.hhs.mass.gov/ibmcognos/bi/?perspective=authoring&pathRef=.public\\_folders%2FMEPHTN%2Fdph%2FPHIT-Reports%2Ftobacco-density-43&id=i89193E0FC7334C7A98D00C8F978E0B20&ui\\_appbar=false&ui\\_n](https://dphanalytics.hhs.mass.gov/ibmcognos/bi/?perspective=authoring&pathRef=.public_folders%2FMEPHTN%2Fdph%2FPHIT-Reports%2Ftobacco-density-43&id=i89193E0FC7334C7A98D00C8F978E0B20&ui_appbar=false&ui_n).
- 27 Missouri Department of Health and Senior Services. Missouri quitline at a glance. Published 2010. Accessed February 4, 2022. <https://health.mo.gov/living/wellness/tobacco/smokingandtobacco/pdf/2010QuitlineReport.pdf>.



## REFERENCES

- 28 California Tobacco Control Program. California tobacco facts and figures: new challenges to tobacco control in California. Published 2018. Accessed February 4, 2022. <https://www.cdph.ca.gov/Programs/CCDC/DCDC/CTCB/CDPH%20Document%20Library/ResearchandEvaluation/FactsandFigures/CATobaccoFactsFigures2018.pdf>.
- 29 Indiana State Department of Health Tobacco Prevention and Cessation Commission. Indiana tobacco control strategic plan. Published 2020. Accessed February 4, 2022. [https://www.in.gov/health/tpc/files/2020-Strategic-Plan\\_PDF\\_FINAL.pdf](https://www.in.gov/health/tpc/files/2020-Strategic-Plan_PDF_FINAL.pdf).
- 30 North Carolina social determinants of health by region. North Carolina State Center for Health Statistics. Accessed February 4, 2022. <https://nc.maps.arcgis.com/apps/MapSeries/index.html?appid=def612b7025b44eaa1e0d7af43f4702b>.
- 31 Justice Map. Accessed February 4, 2022. <http://www.justicemap.org/>.
- 32 Geographic Information Systems: tools for community mapping. Community Tool Box. Published 2019. Accessed December 9, 2019. <https://ctb.ku.edu/en/table-of-contents/assessment/assessing-community-needs-and-resources/geographic-information-systems/main>.
- 33 Longley P, Goodchild M, Maguire D, Rhind D. *Geographic Information Systems and Science*. 3rd ed. Hoboken, NJ: John Wiley & Sons, Inc; 2011.
- 34 QGIS. Accessed February 4, 2022. <https://www.qgis.org/en/site/>.
- 35 TRAIN learning network. Public Health Foundation. Accessed February 4, 2022. <https://www.train.org/main/welcome>.
- 36 QGIS tutorials and tips. QGIS. Accessed February 4, 2022. <https://www.qgistutorials.com/en/>.
- 37 Working with GIS data? librarians can help with that. Syracuse University. Published October 15, 2019. Accessed March 2, 2020. <https://ischoolonline.syr.edu/blog/gis-data/>.
- 38 GIS & open data. Esri. Accessed February 4, 2022. [https://www.esri.com/content/dam/esrisites/sitecore-archive/Files/Pdfs/industries/government/State/GL\\_Guide\\_Esri\\_Gis\\_R4.pdf](https://www.esri.com/content/dam/esrisites/sitecore-archive/Files/Pdfs/industries/government/State/GL_Guide_Esri_Gis_R4.pdf).
- 39 Cincinnati Area Geographic Information System. City of Cincinnati. Accessed February 4, 2022. <http://cagismaps.hamilton-co.org/cagisportal/>.
- 40 Fletcher-Lartey S, Caprarelli G. Application of GIS technology in public health: successes and challenges. *Parasitology*. 2016;143(4):401-415. doi: [10.1017/S0031182015001869](https://doi.org/10.1017/S0031182015001869).
- 41 Miranda M, Casper M, Tootoo J, Schieb L. Putting chronic disease on the map: building GIS capacity in state and local health departments. *Preventing Chronic Disease*. 2013;10:120321. <https://pubmed.ncbi.nlm.nih.gov/23786907/>.
- 42 Esri user groups. Esri. Accessed April 10, 2020. <https://www.esri.com/en-us/about/events/index/user-groups>.
- 43 Williams M, Dubowitz T, Jacobson D, et al. Mapping the gaps: ideas for using GIS to enhance local health department priority setting and program planning. RAND Corporation. Published 2011. Accessed December 9, 2019. [https://www.rand.org/pubs/technical\\_reports/TR1146.html](https://www.rand.org/pubs/technical_reports/TR1146.html).
- 44 Briney A. Overview of public health and GIS. GIS Lounge. Published April 18, 2014. Accessed December 10, 2019. <https://www.gislounge.com/overview-public-health-gis/>.
- 45 Centers for Disease Control and Prevention. *Best Practices User Guide: health communications in tobacco prevention and control*. Published 2018. Accessed November 6, 2018. <https://www.cdc.gov/tobacco/stateandcommunity/bp-health-communications/index.htm>.
- 46 Goodchild M. GIS and modeling overview. Accessed April 22, 2020. <http://www.geog.ucsb.edu/~good/papers/414.pdf>.
- 47 Luke D, Ribisl K, Smith C, Sorg A. Family Smoking Prevention and Tobacco Control Act: banning outdoor tobacco advertising near schools and playgrounds. *American Journal of Preventive Medicine*. 2011;40(3):295-302. doi: [10.1016/j.amepre.2010.11.018](https://doi.org/10.1016/j.amepre.2010.11.018).
- 48 Tobacco Town. ASPIRE Center. Accessed February 4, 2022. <https://aspirecenter.org/projects/tobacco-town/>.
- 49 Rytönen M. Not all maps are equal: GIS and spatial analysis in epidemiology. *International Journal of Circumpolar Health*. 2004;63(1). doi: [10.3402/ijch.v63i1.17642](https://doi.org/10.3402/ijch.v63i1.17642).
- 50 Feature class basics. ArcGIS. Published 2019. Accessed June 30, 2020. <https://desktop.arcgis.com/en/arcmap/10.3/manage-data/geodatabases/feature-class-basics.htm>.
- 51 Shapefiles. ArcGIS. Accessed February 4, 2022. <https://doc.arcgis.com/en/arcgis-online/reference/shapefiles.htm>.
- 52 Census tracts. United States Census Bureau. Accessed April 1, 2020. <https://www2.census.gov/geo/pdfs/education/CensusTracts.pdf>.
- 53 Census blocks and block groups. United States Census Bureau. Accessed April 1, 2020. <https://www2.census.gov/geo/pdfs/reference/GARM/Ch11GARM.pdf>.
- 54 Zhang J, Huang M. 5Ws model for big data analysis and visualization. *2013 IEEE 16th International Conference on Computational Science and Engineering*. 2013;1021-1028. doi: [10.1109/CSE.2013.149](https://doi.org/10.1109/CSE.2013.149).
- 55 Essentials of joining tables. ArcGIS Desktop. Accessed February 4, 2022. <https://desktop.arcgis.com/en/arcmap/10.3/manage-data/tables/essentials-of-joining-tables.htm>.
- 56 What is georeferencing? how to georeference anything. GIS Geography. Published May 6, 2017. Accessed February 4, 2022. <https://gisgeography.com/georeferencing/>.
- 57 Geocoding services. Texas A&M GeoServices. Accessed February 4, 2022. <https://geoservices.tamu.edu/Services/Geocode/default.aspx>.

- 58 Institute of Medicine. *Envisioning The National Health Care Quality Report*. National Academies Press; 2001. Accessed April 7, 2020. [https://www.ncbi.nlm.nih.gov/books/NBK223318/pdf/Bookshelf\\_NBK223318.pdf](https://www.ncbi.nlm.nih.gov/books/NBK223318/pdf/Bookshelf_NBK223318.pdf).
- 59 Missouri Spatial Data Information Service. Accessed February 4, 2022. <https://msdis.missouri.edu/>.
- 60 GeoData@Wisconsin. University of Wisconsin-Madison. Accessed February 4, 2022. <https://geodata.wisc.edu/>.
- 61 Bell B, Hoskins R, Pickle L, Wartenberg D. Current practices in spatial analysis of cancer data: mapping health statistics to inform policymakers and the public. *International Journal of Health Geographics*. 2006;5(1):49. doi: [10.1186/1476-072X-5-49](https://doi.org/10.1186/1476-072X-5-49).
- 62 Licensing, zoning, and retailer density. Counter Tobacco. Accessed November 26, 2018. <https://countertobacco.org/policy/licensing-and-zoning/>.
- 63 Florida mapper. Counter Tools. Accessed February 4, 2022. <https://mapping.countertools.org/florida/>.
- 64 EpiInfo user guide. Centers for Disease Control and Prevention. Published September 16, 2021. Accessed February 4, 2022. <https://www.cdc.gov/epiinfo/support/userguide.html>.
- 65 Free training videos. Tableau. Accessed February 4, 2022. <https://www.tableau.com/learn/training/20194>.
- 66 GRASS GIS. Accessed February 4, 2022. <https://grass.osgeo.org/>.
- 67 QGIS training manual. QGIS. Accessed February 4, 2022. [https://docs.qgis.org/3.10/en/docs/training\\_manual/index.html](https://docs.qgis.org/3.10/en/docs/training_manual/index.html).
- 68 MapInfo Pro. Precisely knowledge communities. Accessed February 4, 2022. <https://community.precisely.com/communities/community-home?communitykey=fe4d1ee2-f1c6-4307-87d2-00bea1344885>.
- 69 Support. GeoDa. Accessed February 4, 2022. <https://geodacenter.github.io/support.html>.
- 70 ArcGIS tutorials. ArcMap. Accessed February 4, 2022. <https://desktop.arcgis.com/en/arcmap/latest/get-started/introduction/arcgis-tutorials.htm>.
- 71 What are map projections? Esri. Published 2016. Accessed July 14, 2020. <https://desktop.arcgis.com/en/arcmap/10.3/guide-books/map-projections/what-are-map-projections.htm>.
- 72 Wang C. Usability evaluation of public web mapping sites. *International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*. 2014;XL-4:285-289. doi: [10.5194/isprsarchives-XL-4-285-2014](https://doi.org/10.5194/isprsarchives-XL-4-285-2014).
- 73 Hardt N. Neighborhood-level hot spot maps to inform delivery of primary care and allocation of social resources. *The Permanente Journal*. 2013;17(1):4-9. doi: [10.7812/TPP/12-090](https://doi.org/10.7812/TPP/12-090).
- 74 Miranda M, Casper M, Tootoo J, Schieb L. Putting chronic disease on the map: building GIS capacity in state and local health departments. *Preventing Chronic Disease*. 2013;10:120321. doi:[10.5888/pcd10.120321](https://doi.org/10.5888/pcd10.120321).
- 75 Mayfield M, Chatman B, Davis R, Kephart L. Leveraging GIS and store mapping tools to depict and address disparities. Presented at the Surveillance & Evaluation Webinar Series; May 30, 2019. Accessed December 9, 2019. [http://tacenters.emory.edu/documents/netconference\\_docs/SE2019/053019\\_leveraging-gis-and-store-mapping\\_SEWebinar\\_slides.pdf](http://tacenters.emory.edu/documents/netconference_docs/SE2019/053019_leveraging-gis-and-store-mapping_SEWebinar_slides.pdf).
- 76 Smoke-Free. New York City Housing Authority. Accessed February 4, 2022. <https://www1.nyc.gov/site/nycha/residents/smoke-free.page>.
- 77 Section508.gov. Accessed February 4, 2022. <https://www.section508.gov/>.
- 78 Luan H, Law J. Web GIS-based public health surveillance systems: a systematic review. *ISPRS International Journal of Geo-Information*. 2014;3(2):481-506. doi: [10.3390/ijgi3020481](https://doi.org/10.3390/ijgi3020481).
- 79 US Department of Health and Human Services. Preventing tobacco use among youth and young adults: a report of the Surgeon General. Published 2012. Accessed September 14, 2018. <https://www.ncbi.nlm.nih.gov/books/NBK99237/>.
- 80 Montana tobacco retailer mapper. Montana Department of Public Health & Human Services. Accessed December 10, 2019. <https://dphhs.mt.gov/assets/MTUPPapp/index>.
- 81 Smoke-free and tobacco-free maps and dashboards. North Carolina Department of Health and Human Services. Accessed July 13, 2022. <https://tobaccopreventionandcontrol.dph.ncdhhs.gov/maps/maps.htm>.

