Using Leaflet.js to Interactively Map the Opioid Crisis

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Abstract

Five times as many Americans died from opioid overdose in 2016 than did five years earlier. However, the opioid crisis has not affected every part of the country equally. County public health officials may be unaware of how the severity of the crisis in their community compares regionally and nationally. To address this issue, NORC at the University of Chicago partnered with the USDA to create The Opioid Misuse Community Assessment Tool (opioidmisusetool.norc.org). The tool displays county-level overdose rates across the nation, with overlays of American Community Survey and Bureau of Labor Statistics data to allow users to better understand correlates of overdose burden within their communities, such as high rates of poverty, disability, and injury-prone employment. This presentation focuses on the process of building the tool using the JavaScript library Leaflet.js, and decisions that were made to ensure the visualization had a high and informative impact on its audience. The basics of creating interactive maps for the web will be covered, as well as challenges inherent in interactive geographic visualization.

Key Words: Leaflet.js, interactive graphic, geographic visualization

1. Description of the Tool

Prescription and illicit opioids killed more than 47,000 people in 2017, nearly six times the number in 1999[1]. The toll of the epidemic is so great that it contributed to the first decline in U.S. life expectancy since 1993[2]. However, the magnitude of the crisis is not evenly distributed throughout the country. As such there is the need for local-leaders to have access to relevant information in a user-friendly manner. The USDA's Office of Rural Development partnered with the Walsh Center for Rural Health Analysis at NORC at the University of Chicago to create the Opioid Misuse Community Assessment Tool to assist with building grassroots solutions for prevention, treatment, and recovery. The Opioid Misuse Community Assessment Tool allows researchers, policymakers, journalists, and the general public to create county-level maps illustrating the relationship between community and population demographics and fatal drug overdoses—including opioids—in the United States[3]. Insights derived from this tool can be used to target resources and interventions, and inform media coverage related to overdose deaths in the U.S. The tool maps the drug overdose rate at the county level throughout the U.S., and enables users to overlay substance misuse data against socioeconomic, census and other public information. Our tool represents an innovation in comparison with other similar interactive maps through its ease of use and multivariate design.

1.1 Tool Features

The Opioid Misuse Community Assessment Tool allows the user to view data about the drug overdose crisis in the United States across a variety of formats.

Upon opening the tool the user is met with a county-level map of drug overdose death rates in the United States aggregated over the years 2013 to 2017. The header bar allows the user to switch between viewing death rates for all drugs or opioids only, change the timeframe from 2013-2017 to 2008-2012, zoom, filter between urban and rural counties, and overlay Native American reservations onto the map. The other major map manipulations are the list of bivariate mapping options on the sidebar. Upon clicking on one of these variables, which include demographic and employment information, translucent circles of varying sizes representing the variable will appear, allowing users to clearly see how a given measure relates to the baseline fatal overdose rate.

Clicking on a county and selecting "More Information" brings the user to a county detail page. This webpage includes overdose rate and demographic information about that county, and how it compares statewide and nationally.

1.2   Data Sources

Due to the use of multiple different systems for coding causes of death, some opioid overdose deaths are reported as "general drug overdose" deaths. Acknowledging this data quality issue, the tool presents age-adjusted mortality rates for the population aged 15 to 64 for both opioid and all drug related overdoses. The data come from the National Vital Statistics System multiple cause of death data file, and were downloaded from CDC Wonder web portal[4]. The combined population estimates for the time period (either 2008-2012 or 2013-2017) are the denominator for the mortality rates. Five-year average mortality rates were used for this tool in order to maximize the number of counties with a reliable age-adjusted mortality rate. If a county has fewer than 20 deaths over the five-year time period, the mortality rate is considered "unreliable" and we present the crude mortality rate. For counties with fewer than 10 deaths over the five-year time period, the number of deaths is suppressed, and therefore a mortality rate is not provided. However, when possible, we have calculated the maximum crude mortality rate based on the population and the assumption of less than 10 deaths.

The bivariate mapping options originate from two sources. The demographic data comes from the Census Bureau American Community Survey 5-year estimates for 2008-2012 and 2013-2017. The employment data comes from the Bureau of Labor Statistics Quarterly Census of Employment and Wages. This dataset was released annually, but averaged over 2008-2012 and 2013-2017 in order to align with the death rate and demographic data.

The Urban/Rural filter is consistent with the USDA's urbanicity definition[5], which in turn is based on the Office of Management and Budget's urban influence codes. The USDA defines a county as urban if it has an urban influence code of 1 or 2, denoting that a county has at least one urbanized area of 50,000 or more population, plus adjacent territory that has a high degree of social and economic integration with the core as measured by commuting ties[6]. Every county that does not have an urban influence code of 1 or 2 is defined as rural.

Finally, the Native American Reservations boundaries come from the U.S. Geological Survey National Atlas[7].

2. How the Tool was Built

2.1 Data Cleaning

The data processing steps of the tool was consistent across all datasets. (1) Data were downloaded from the sources listed above; (2) data was manipulated in SAS, where every field of the dataset was dropped except for a federal information systems processing (or FIPS) code indicator of county or state and the to be mapped within the tool; and finally (3) data was imported into R[8] using the *readr* package[9], appended to a shapefile of counties/states using the *rgdal* package[10], and exported as TopoJSON using the *geojsonio* package[11].

The geographic data format used within the tool, TopoJSON (Topographic JavaScript Object Notation), is a widely adopted geographic data standard that is able to be read by JavaScript. It is widely seen a more lightweight alternative to GeoJSON (Geographic JavaScript Object Notion). Unlike GeoJSON, TopoJSON polygon elements share borders, eliminating much of the redundancy in the part of the file that describes how to draw each geographic element. We reduced the size of our TopoJSON file further by simplifying the geographies of the county polygons using the Mapshaper web utility[12].

2.2 Structure of the Tool

Because of the complications of spatial data, the detailed customization of the web design, and the necessity of having multiple pages in the web app, the Opioid Misuse Community Assessment Tool was programmed directly in HTML, CSS, and JavaScript rather than from a one language framework such as Python Django[13] or Ruby on Rails[14].

HTML, or Hypertext Markup Language, provides the structure of the web page. All of the text of the web page is contained within the HTML, enclosed within descriptive tags such as paragraph, button, header, etc. HTML allows for very limited formatting on its own. Figure 1 shows a screenshot of the webpage with its HTML code, but no CSS or JavaScript.

Figure 1 - Screenshot of rendered HTML of the Tool

CSS, which stands for Cascading Style Sheets, allows for the user to describe the appearance of HTML tags. The CSS of the Opioid Misuse Community Assessment tool is built on top of the most popular front-end framework on the web, Bootstrap. Bootstrap classes were added to many of the HTML elements in the tool to provide syntactic conveniences for stylings such as centering the text of buttons. The CSS of the final version of the tool was highly customized, however, consisting of over 4000 lines of code.

Unlike HTML, CSS is sensitive to the size of the user's window to the web page and can change accordingly. While the CSS of the tool is programmed such that the map controls and county detail pages appear and disappear depending on how much screen space they are allotted, the tool is not optimized for mobile phone use. A county map of the United States contains too much detail for the user of a mobile phone browser to interact without difficulty. Instead, users are greeted with a pop up asking them to use their browser. CSS controls the styling of the web page, but not the content or the interactivity. Figure 2 shows a screenshot of the webpage with its HTML and CSS code, but no JavaScript.

Figure 2 – Screenshot of the Tool with only HTML and CSS, no JavaScript

JavaScript provides the interactivity of the tool, and it's also the format the data. The JavaScript for the tool was divided into three parts based on the popular software architecture model-view-controller. The *model* JavaScript script contains the data structure of the web page, as well as all the functions used to subset the data to only that which will be displayed in the user interface. The *view* script controls the display of the data fed to it by the *model* script, containing all code relating to the appearance of the map, for instance. The *controller* script deals with all user input for the tool. While the *model* and *view* scripts are essentially lists of objects and functions, the *controller* script can be boiled down to just a list of the buttons on the web page, and the functions that they call when clicked. Figure 3 shows a screenshot of the webpage with its all of its code running.
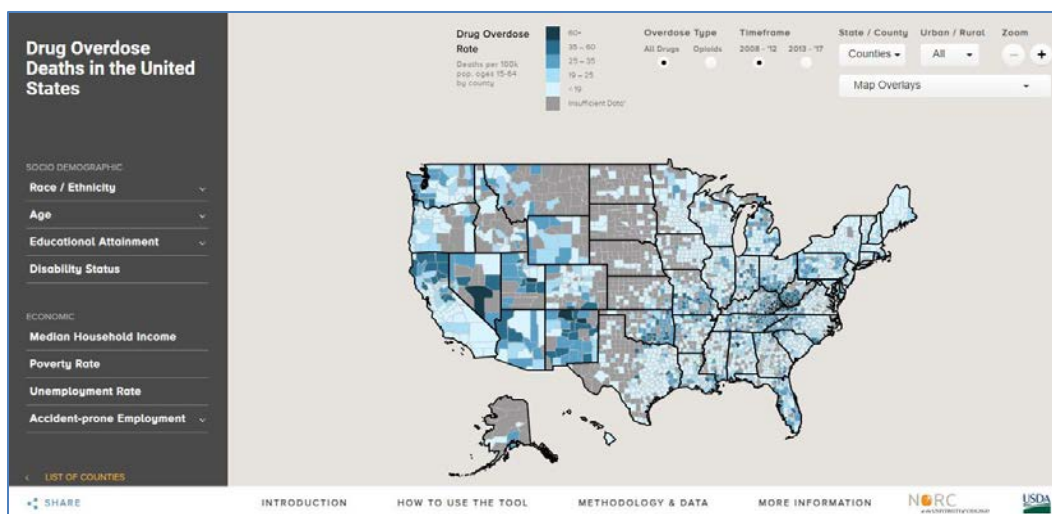
Figure 3 – Screenshot of the Tool with all Code Running

In order to reduce dependencies and speed processing, the tool was designed to call as few external packages as possible. Below is a list of the JavaScript libraries used within the tool. The *Jquery, Underscore,* and *Leaflet* are best understood as lists of functions, while the remaining three packages are extensions of functions found in other libraries.

- *Jquery:* Jquery is the most popular JavaScript library. It allows the programmer to edit HTML using the convenient syntax of CSS selectors rather than the more obtuse native JavaScript HTML manipulation[15].
- *Underscore* – Underscore is a tiny, popular library consisting of 100 or so utility functions for iterating over objects and arrays in JavaScript without the necessity of using JavaScript's cumbersome native looping syntax [16].
- *Leaflet* – Leaflet is a lightweight, open source JavaScript library used for mapping built in D3. Unlike competitors such as the Google Maps API, Leaflet allows for customization of the web map to draw vector tiles using the SVG standard, but does not offer services such as geocoding and routing[17].
- *Leaflet-omnivore* – Leaflet-omnivore extends Leaflet's SVG standard to allow for the display of TopoJSON rather than GeoJSON[18].
- *Perfect-Scrollbar* – Perfect Scrollbar is a library that transforms the appearance of scrollbars to a sleek, minimalist design [19].
- *Jquery Print* – Jquery Print allows for sub setting the web page upon printing. This library is what allows the user to print a county detail page without the rest of the website appearing in the background [20].

3. Development History

3.1   Aesthetic Decisions

The original mockup of the tool, Figure 5, went through a series of critiques and iteratively improved designs that ended with the tool's current design. The original mockup was criticised as giving the user too many features, overwhelming them. Instead we focused on creating user stories- imagining what data our end users would want from the Opioid Misuse Community Assessment Tool, and how the user interface could be simplified to emphasize the findability of that data.
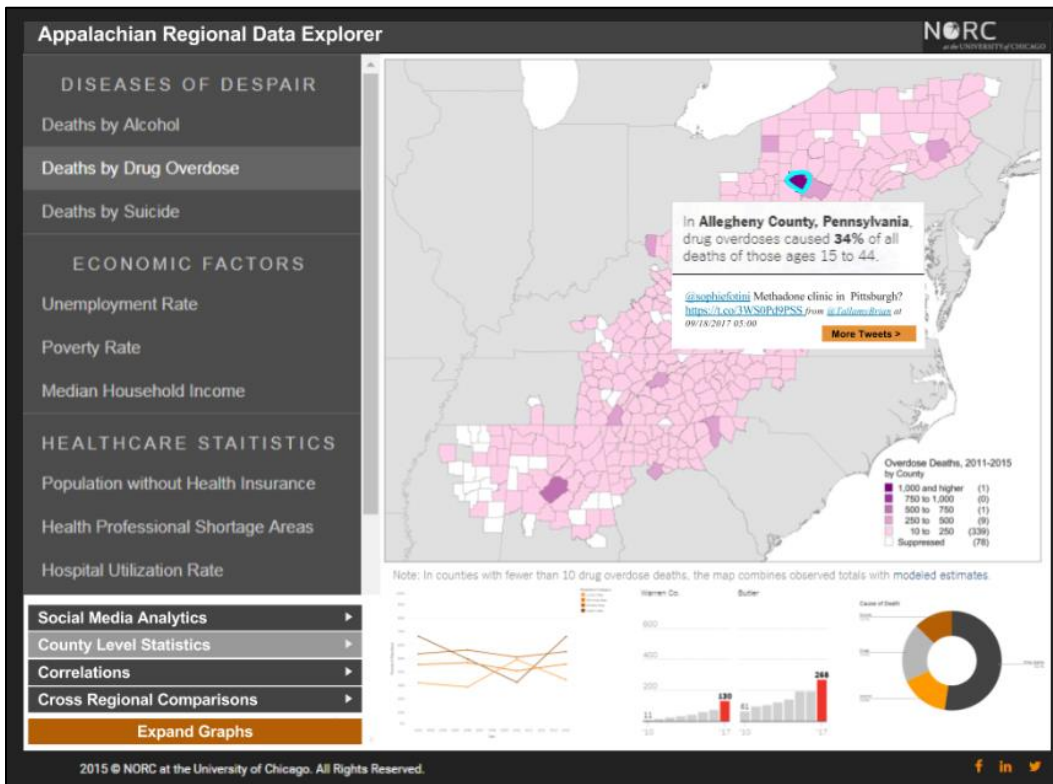
Figure 5 – Early Mockup of the Tool

The most difficult aesthetic decision was how to best create the multivariate map that is the visual centerpiece of the tool. Figures 6 and 7 show early attempts at multivariate mapping. The bivariate choropleth map in figure 6 was visually the most pleasing at all zoom levels, but too difficult to interpret for the lay user. The cross-hatching method in Figure 7 had no issues with interpretability or zoom level, but was visually so unappealing it was not long considered. Thus, it was settled on the proportional symbol mapping scheme currently used in the tool. The proportional symbols scale with zoom level, so only at the highest zoom level do they ever seem to blend together. Unfortunately, the visual bias of the Eastern United States appearing to be more dense with all variables than the west persist, simply due to vary county sizes across the country.
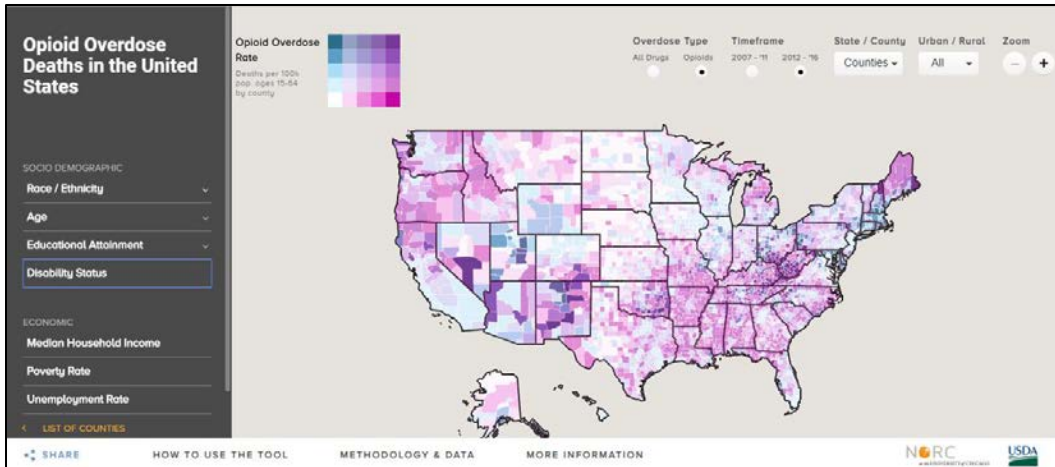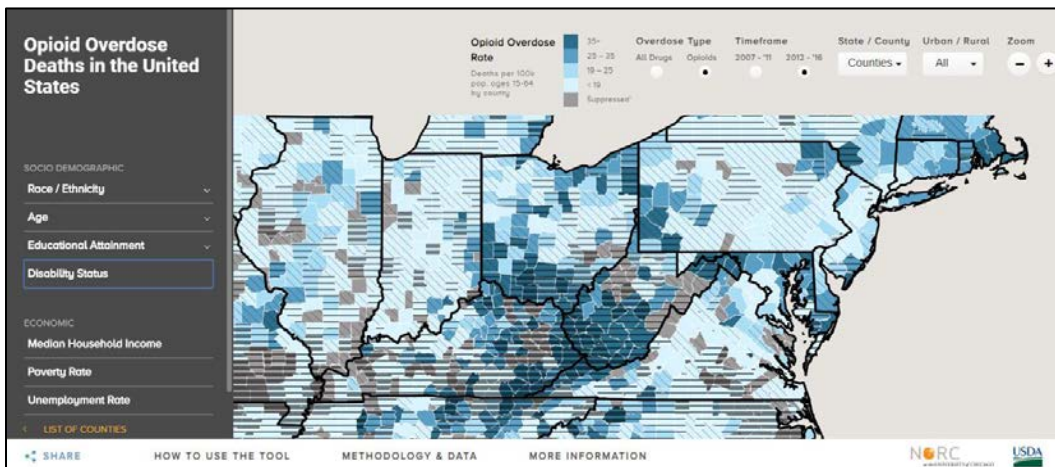
Figure 6 - Bivariate Choropleth Map

Figure 7 – Cross Hatching Bivariate Map

Another aesthetic decision concerned accessibility. Making 508 compliant interactive graphics is always challenging. In the Opioid Misuse Community Assessment Tool, providing descriptive alternative text for the bivariate map proved impossible, as it changed drastically as the user interacted with it. As an alternative, NORC provided a list of the counties in the tool at the end of the sidebar. Screen reader users can click on the list of counties, and find their county detail page of interest.

3.2   User Testing

Two major modifications to the site were arrived at after doing user testing. First, many users did not understand that the demographic information presented in the county detail page represented the county as a whole, rather than just those who died of a drug overdose. A large bolded footnote was added to the county detail page to dissuade this notion. Second, it was discovered that many of our users were not interested in mapping overdose deaths across the United States, but rather just wanted an accessible way to view information about their county of interest. To increase the findability of data regarding how an individual county was coping with the opioid crisis, we added a button on the county detail page that shows change across all data points offered within the two time periods.

Acknowledgements

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