Mapping Hospital Accessibility with OpenStreetMap

William Edmisten

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Topics Covered

Analyzing hospital accessibility with OSM

1. What is hospital accessibility?
2. Why is it important?
3. How do you measure hospital accessibility with OSM?
4. How does hospital accessibility compare by state?

Visualizing the results

5. How to visualize the results?
6. What are the implications of the results?

What is Hospital Accessibility?

- Many components, but focusing on **geographic** accessibility
- Driving time to nearest hospital

Why is Measuring Hospital Accessibility Important?

- 136 rural hospital closures from 2010 to 2021
- 65.83% of designated Health Professional Shortage Areas are rural
- Distance to hospital in an emergency correlates with increased mortality
  - 10km distance increase → 1% increase in mortality

How to measure hospital accessibility with OSM?

Finding Hospitals

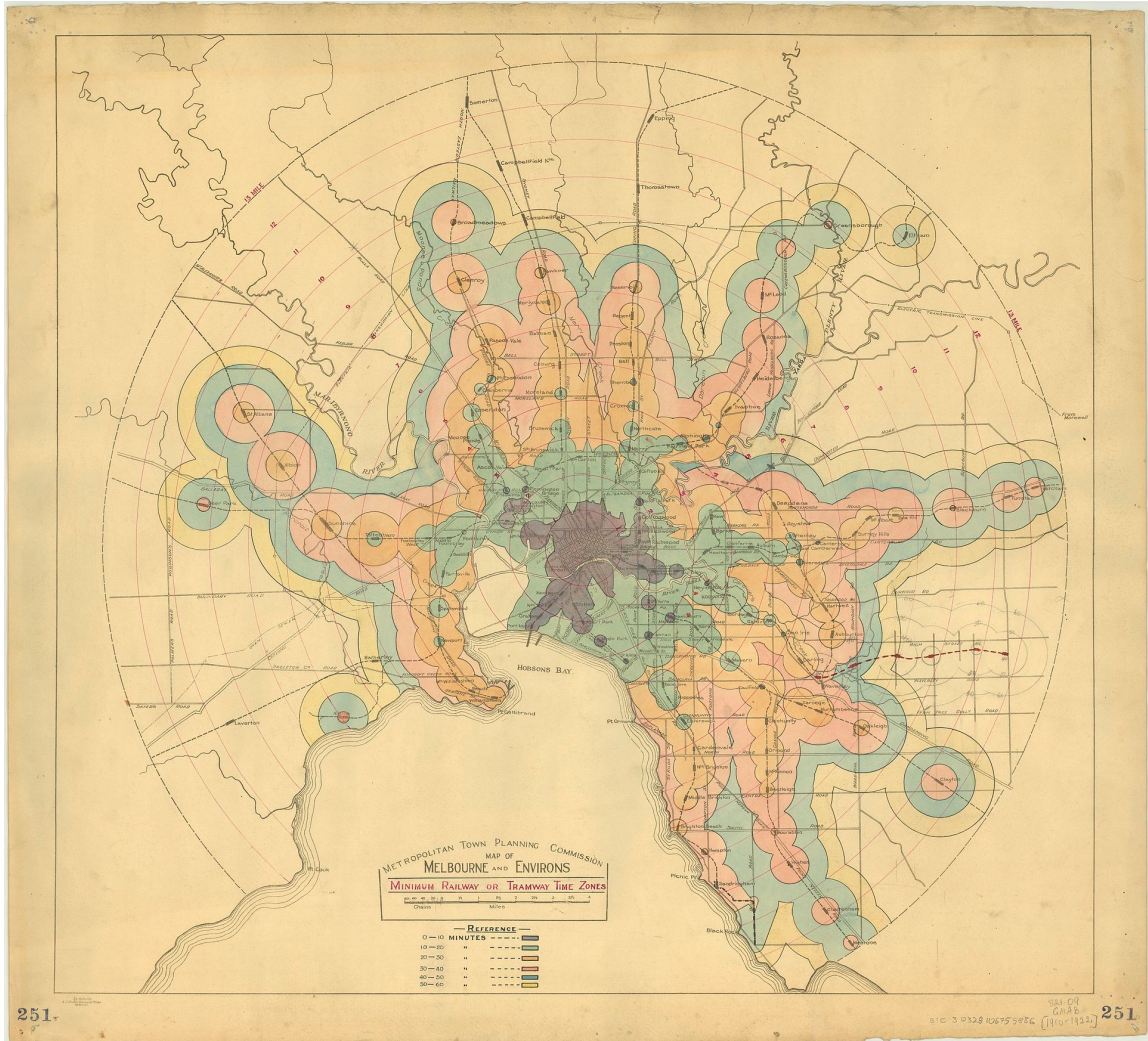
- amenity=hospital
- PostGIS + osm2pgsql

```
SELECT ST_AsText(ST_Transform(way,4326)) as centroid,osm_id,name
FROM planet_osm_point
WHERE amenity='hospital';
```

```
SELECT ST_AsText(ST_Transform(ST_Centroid(way),4326)) AS centroid, osm_id, name
FROM planet_osm_polygon
WHERE amenity='hospital';
```

Isochrone Maps

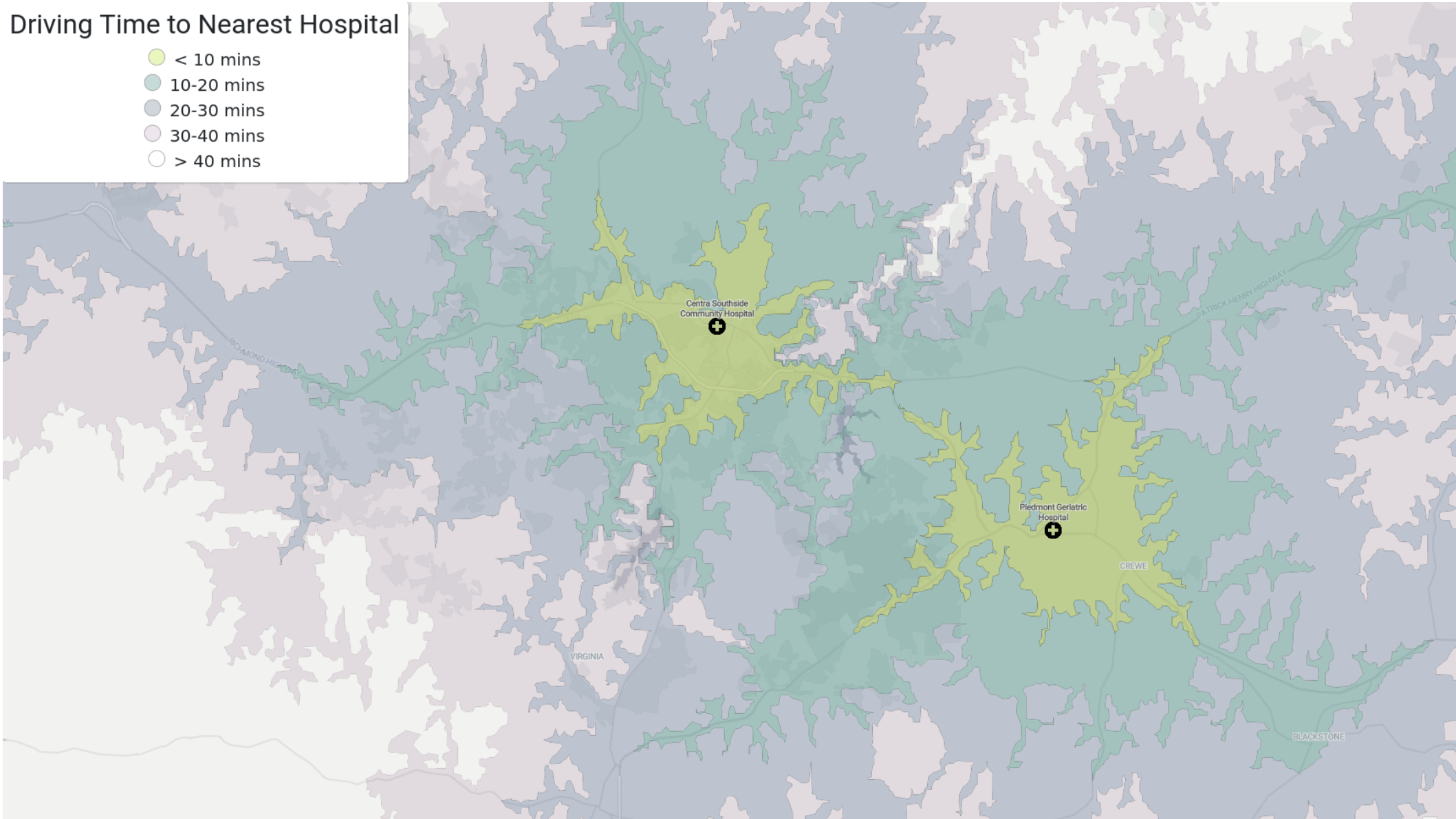
- Shows travel time from one place to many other places
- Supported by many OSM routing services (Valhalla, Graphhopper)



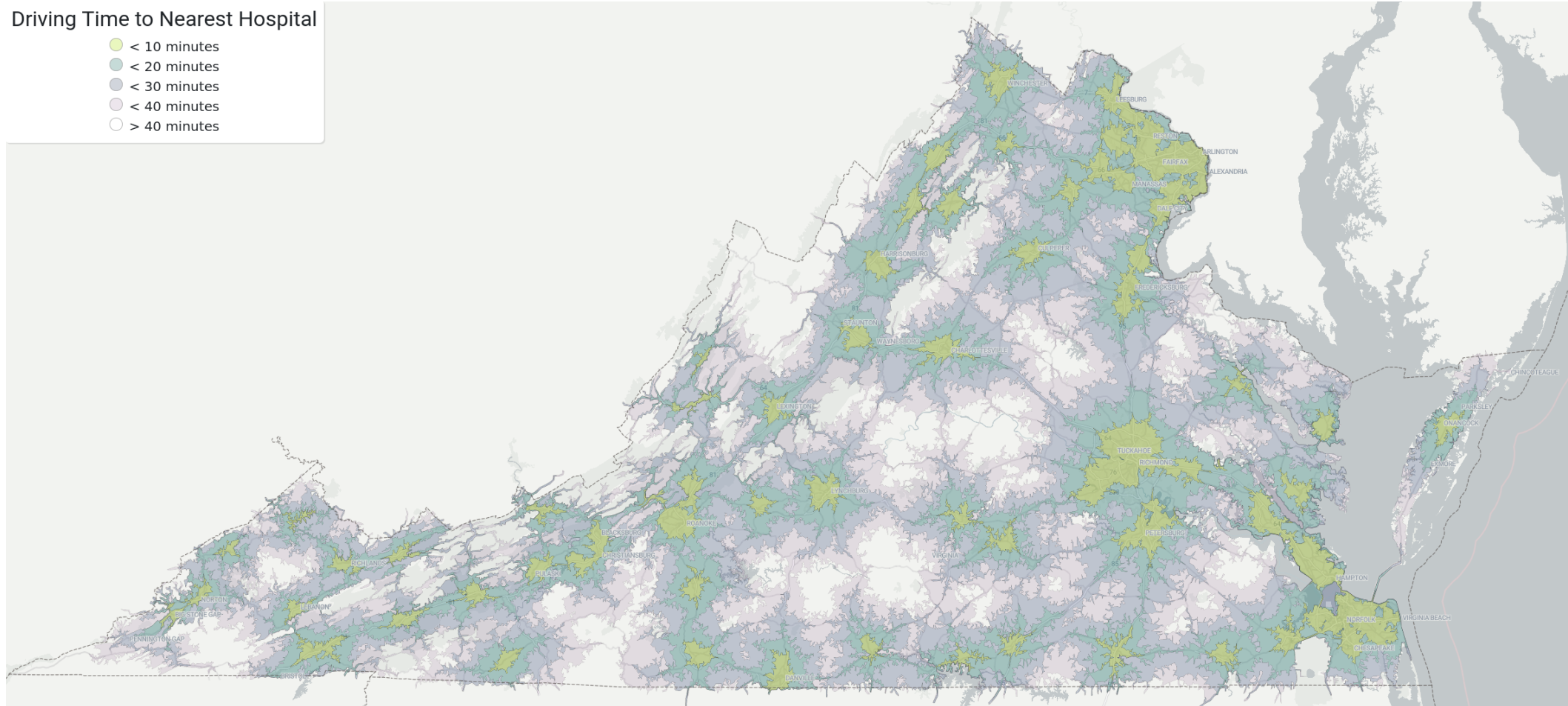
Source: wikipedia

General Approach

- Iterate over every hospital
- Find the isochrone polygons in 10 minute intervals (10-40 mins)
- Take the union of each time interval


Driving Time to Nearest Hospital
< 10 mins
10-20 mins
20-30 mins
30-40 mins
> 40 mins
Centra Southside Community Hospital
Piedmont Geriatric Hospital
RICHMOND HIGHWAY
PATRICK HENRY HIGHWAY
CREWE
VIRGINIA
BLACKSTONE

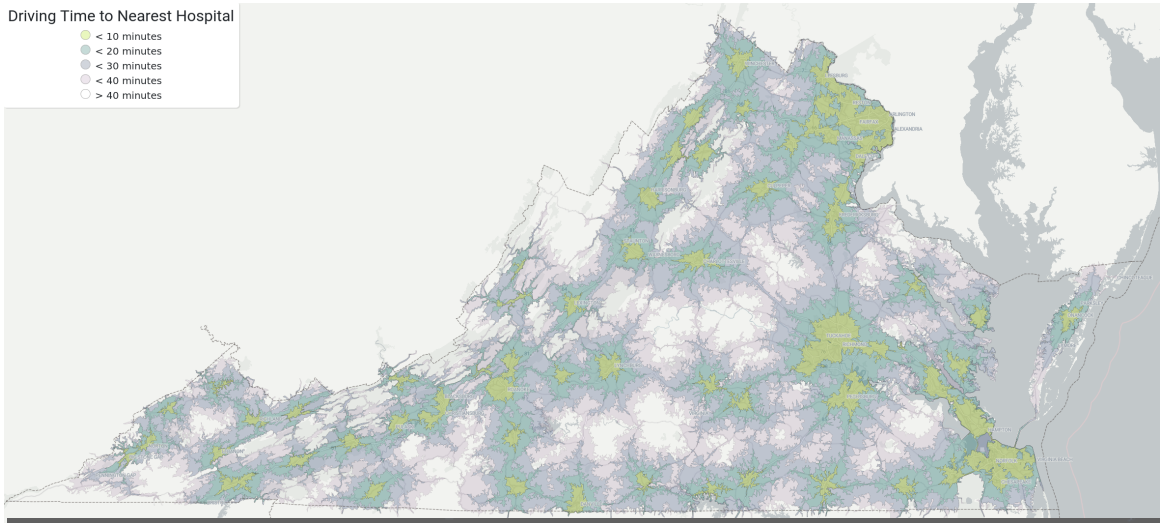
All Virginia Hospital Isochrones

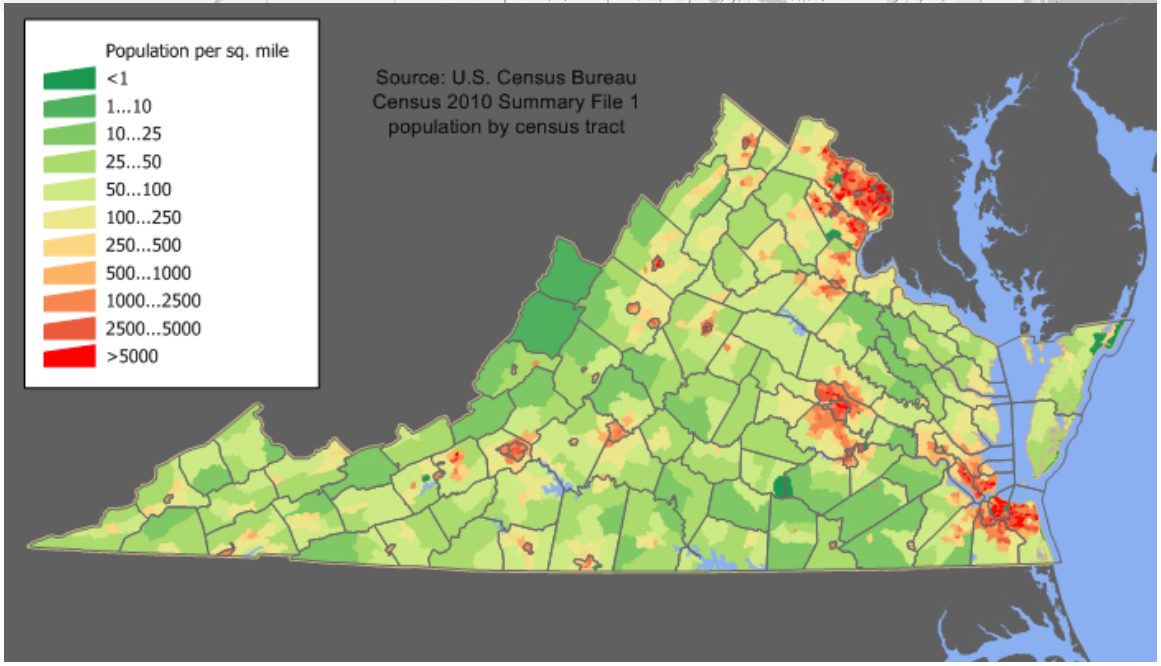


Hospital Driving Times

Population Density

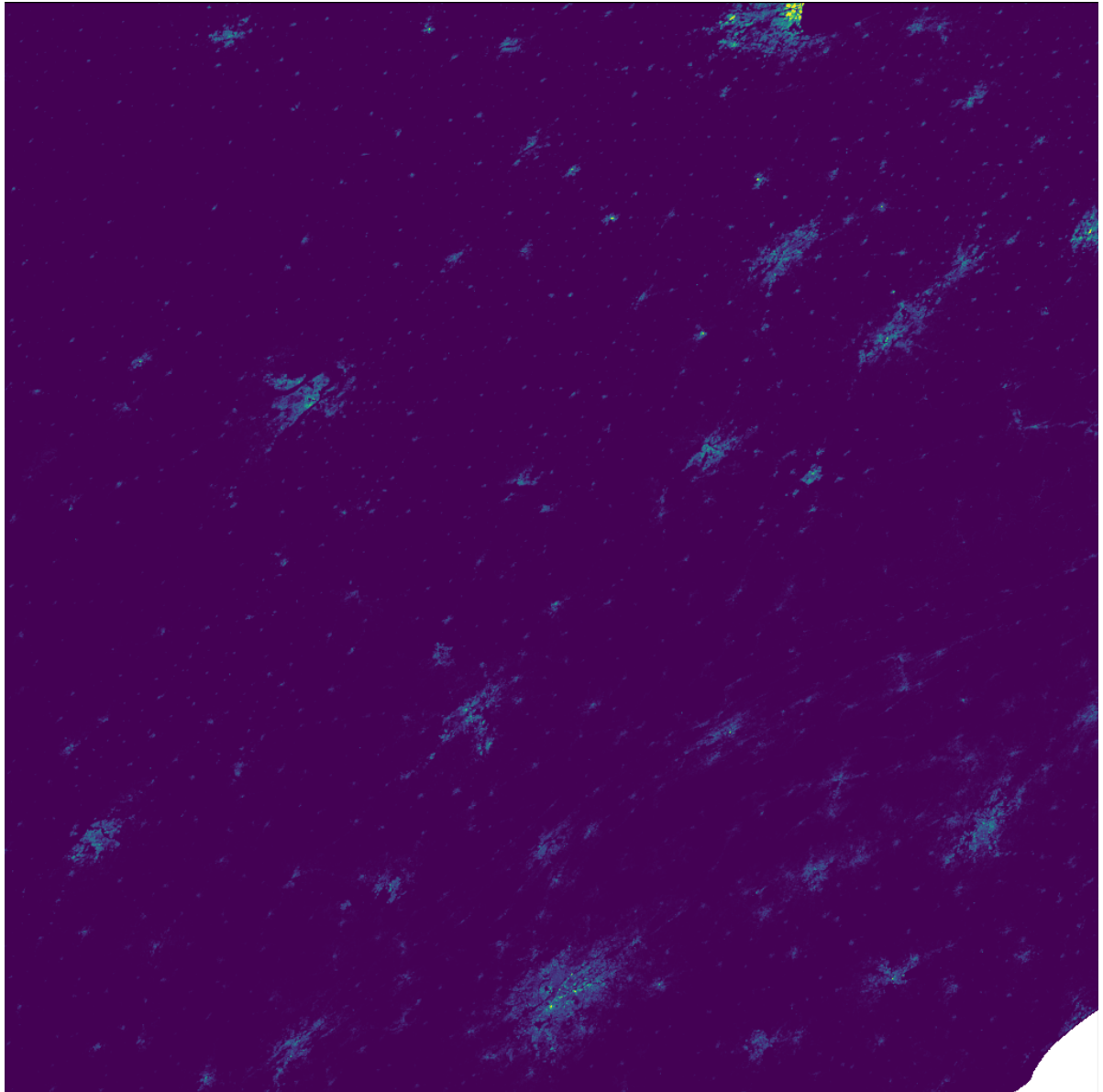
Source: wikipedia





Estimating Population within an Isochrone

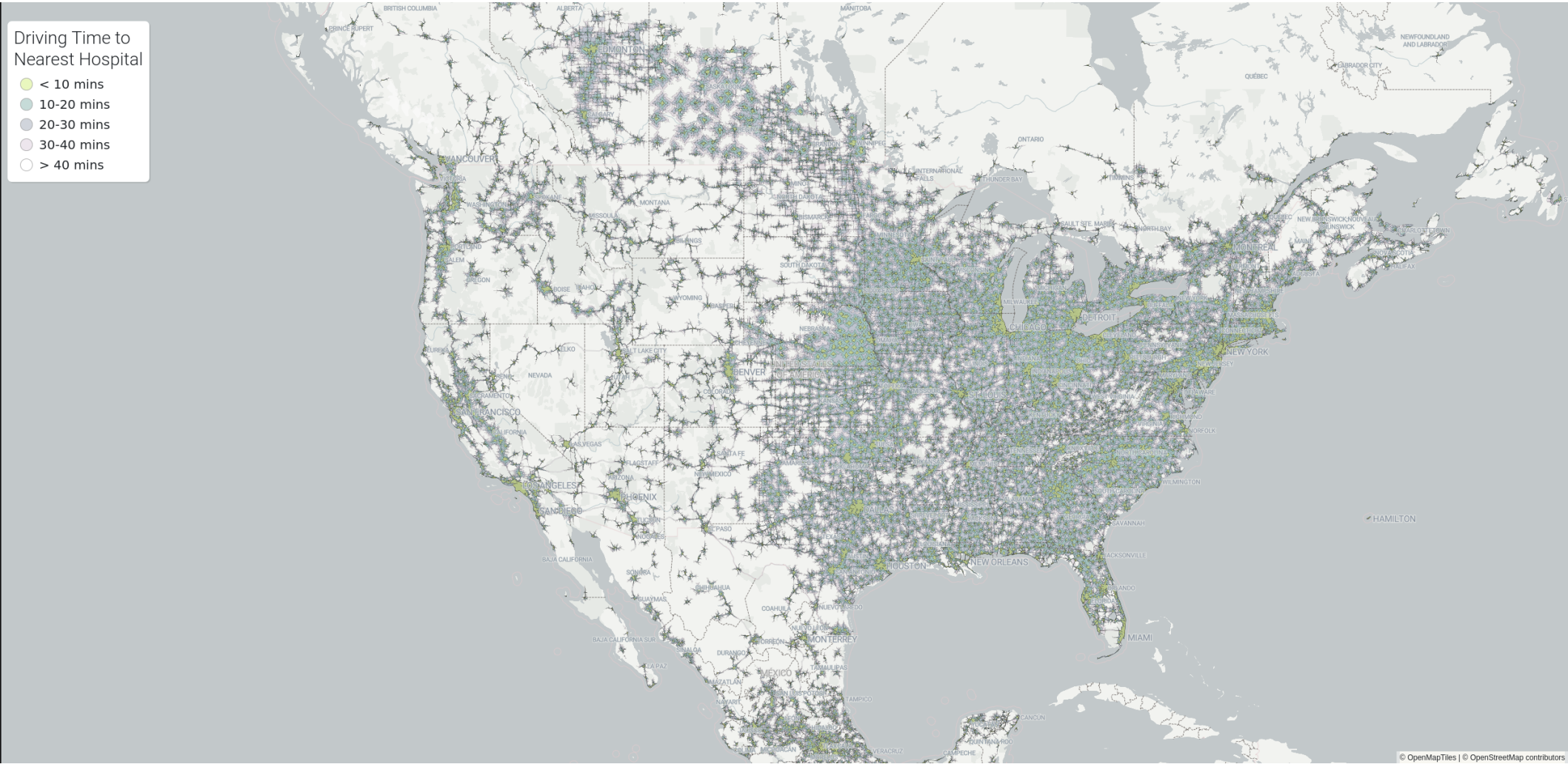
- EU’s Global Human Settlement (GHS) Population dataset
- Provides high-granularity population estimates
- Python library **rasterstats**



Virginia Statistics

Based on GHS 2020 population estimates

Travel Time (mins)	Population	VA Population (%)	VA Area (%)
10	5,514,068	65.38	9.11
20	7,454,683	88.40	31.68
30	8,094,637	95.98	59.29
40	8,343,513	98.94	80.44


Driving Time to Nearest Hospital
< 10 mins
10-20 mins
20-30 mins
30-40 mins
> 40 mins
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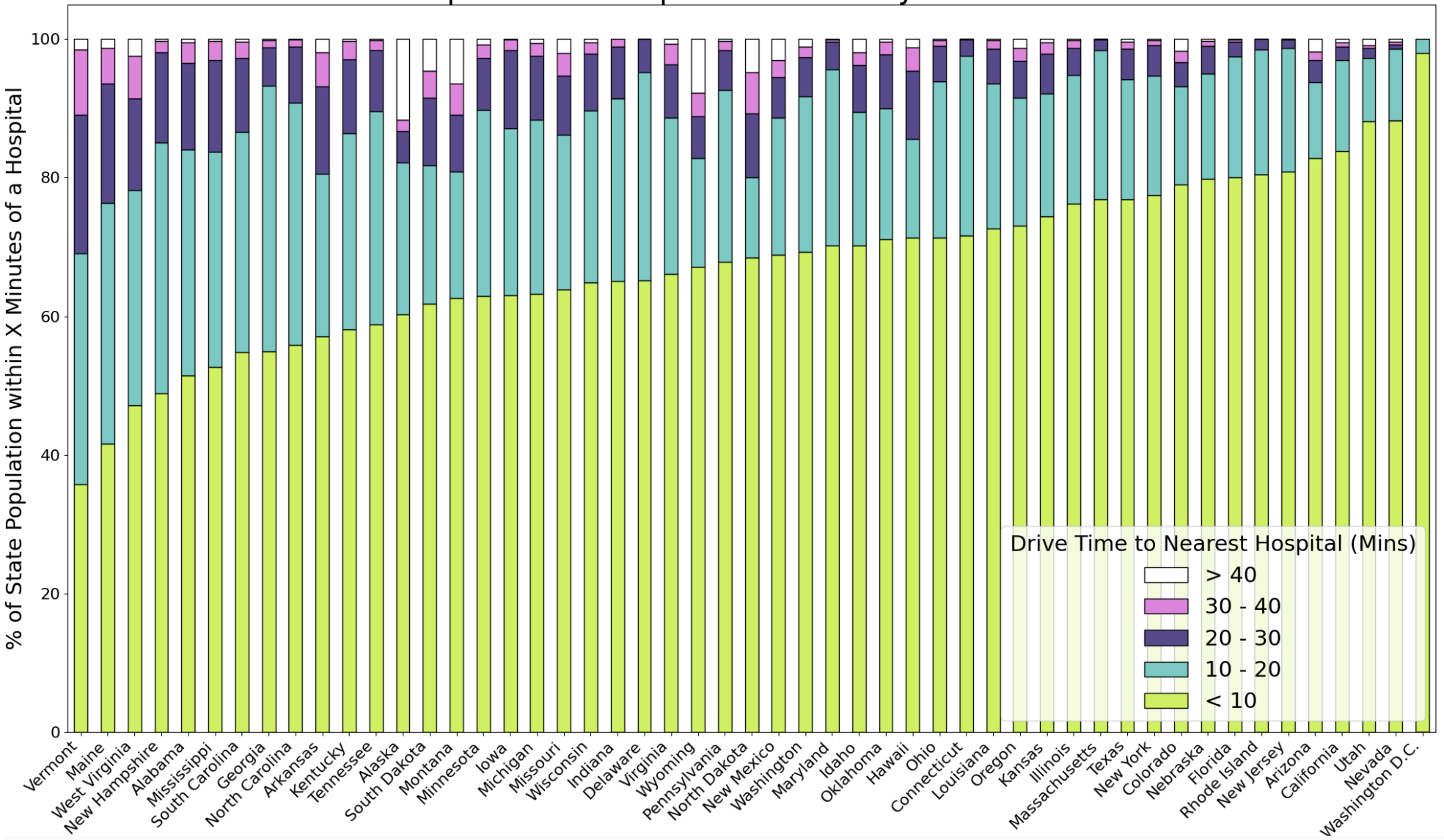
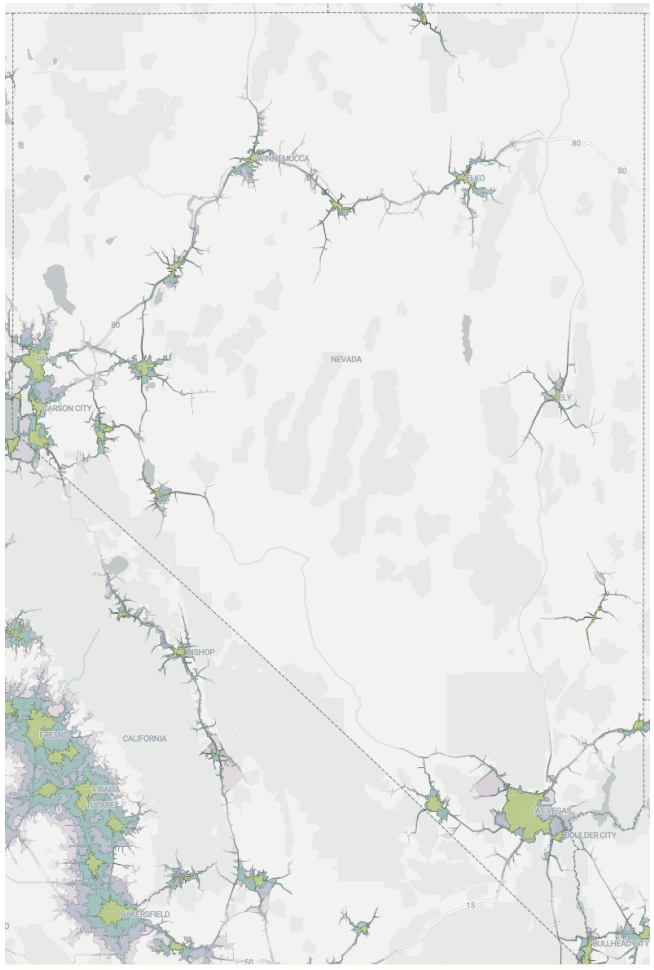
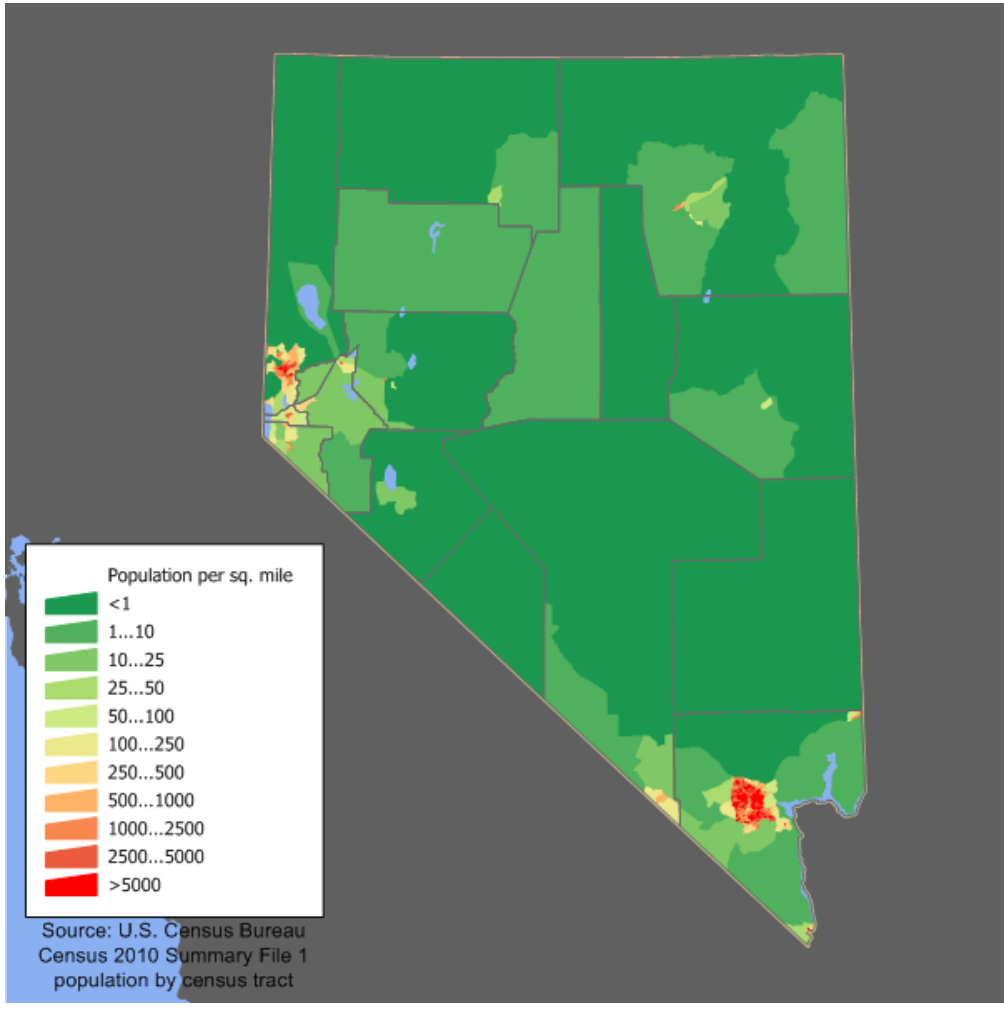
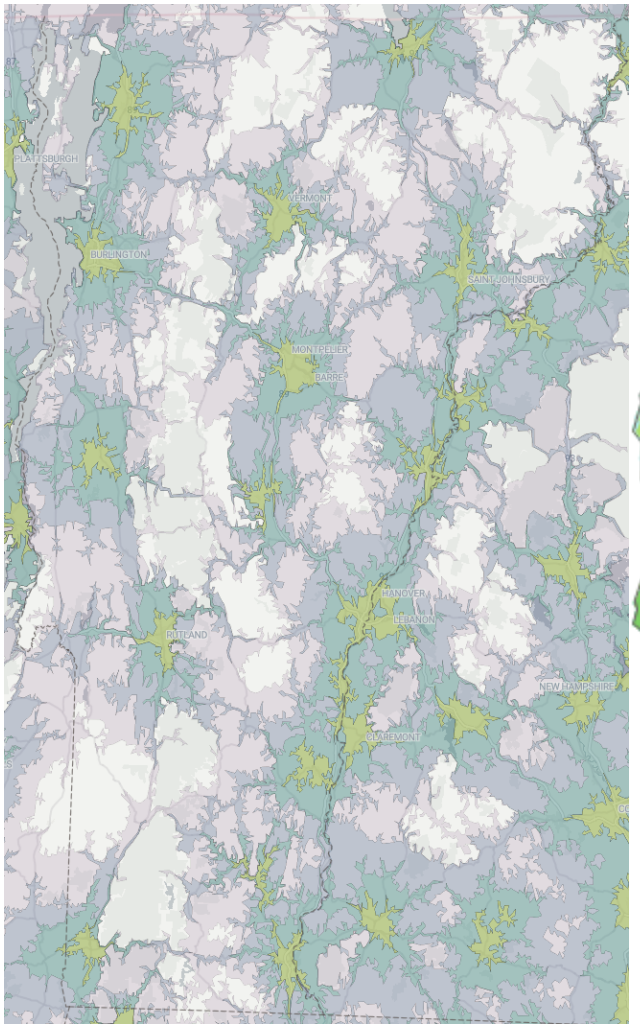

Comparison of Hospital Accessibility Across States
% of State Population within X Minutes of a Hospital
0
20
40
60
80
100
Drive Time to Nearest Hospital (Mins)
> 40
30 - 40
20 - 30
10 - 20
< 10
Vermont
Maine
West Virginia
New Hampshire
Alabama
Mississippi
South Carolina
Georgia
North Carolina
Arkansas
Kentucky
Tennessee
Alaska
South Dakota
Montana
Minnesota
Iowa
Michigan
Missouri
Wisconsin
Indiana
Delaware
Virginia
Wyoming
Pennsylvania
North Dakota
New Mexico
Washington
Maryland
Idaho
Oklahoma
Hawaii
Ohio
Connecticut
Louisiana
Oregon
Kansas
Illinois
Massachusetts
Texas
New York
Colorado
Nebraska
Florida
Rhode Island
New Jersey
Arizona
California
Utah
Nevada
Washington D.C.

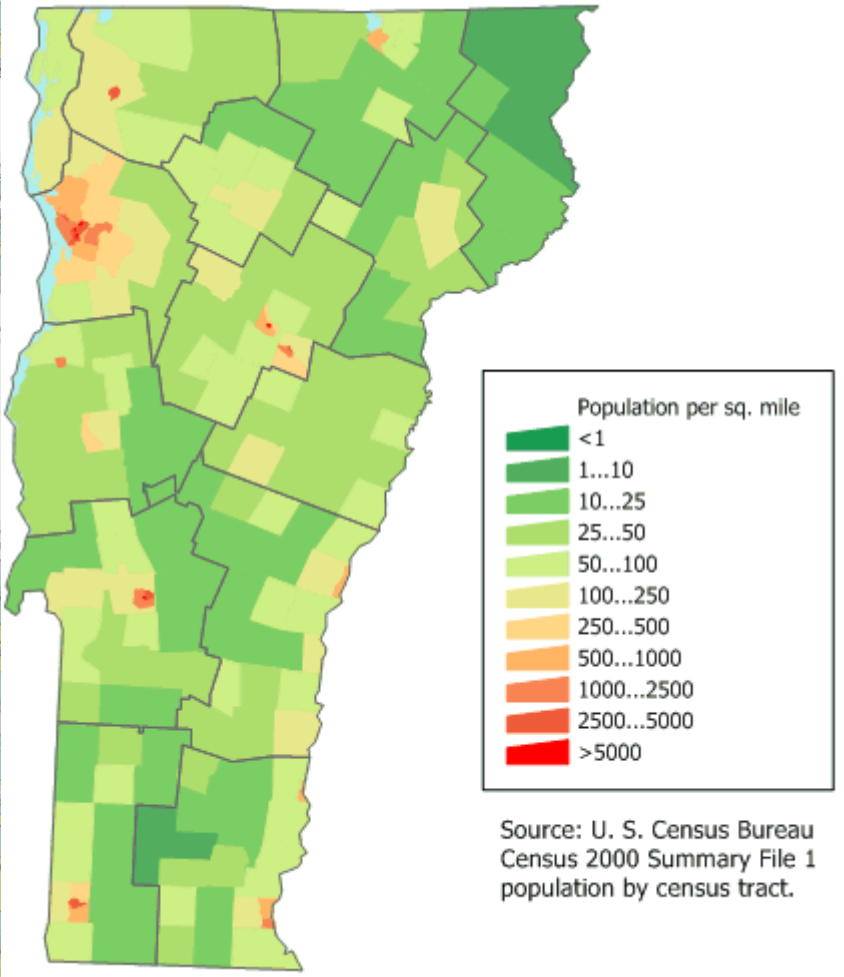
Nevada


WINNEMUCCA
ELKO
80
NEVADA
CARSON CITY
BISHOP
CALIFORNIA
FRESNO
VISALIA
LAS VEGAS
BOULDER CITY
BAKERSFIELD
15
MULLHEAD CITY

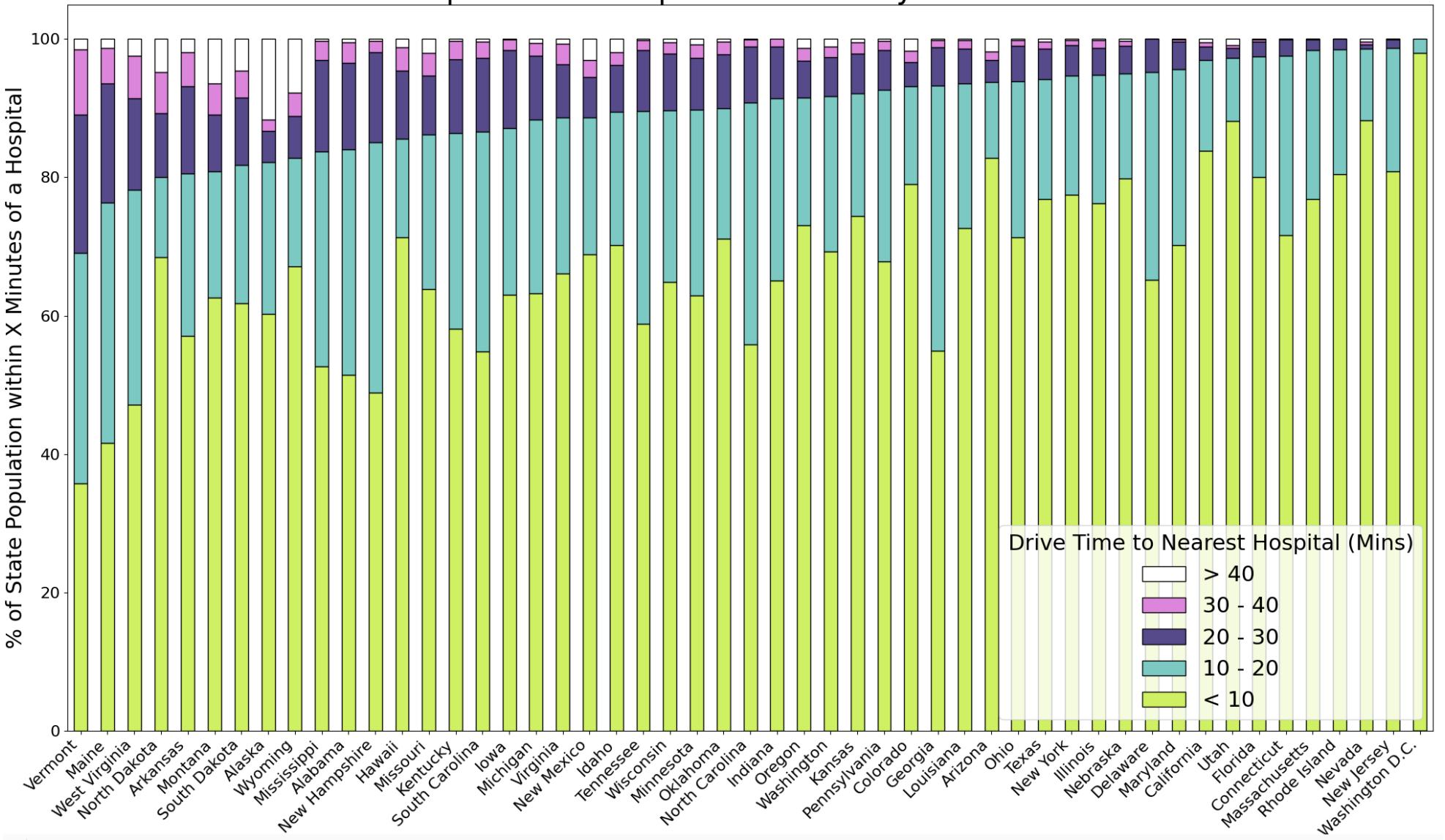

Population per sq. mile
<1
1...10
10...25
25...50
50...100
100...250
250...500
500...1000
1000...2500
2500...5000
>5000
Source: U.S. Census Bureau
Census 2010 Summary File 1
population by census tract

Vermont





Source: U. S. Census Bureau
Census 2000 Summary File 1
population by census tract.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30 - 40
20 - 30
10 - 20
< 10
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Maine
West Virginia
North Dakota
Arkansas
Montana
South Dakota
Alaska
Wyoming
Mississippi
Alabama
New Hampshire
Hawaii
Missouri
Kentucky
South Carolina
Iowa
Michigan
Virginia
New Mexico
Idaho
Tennessee
Wisconsin
Minnesota
Oklahoma
North Carolina
Indiana
Oregon
Washington
Kansas
Pennsylvania
Colorado
Georgia
Louisiana
Arizona
Ohio
Texas
New York
Illinois
Nebraska
Delaware
Maryland
California
Utah
Florida
Connecticut
Massachusetts
Rhode Island
Nevada
New Jersey
Washington D.C.

Challenges

Psychiatric Hospitals

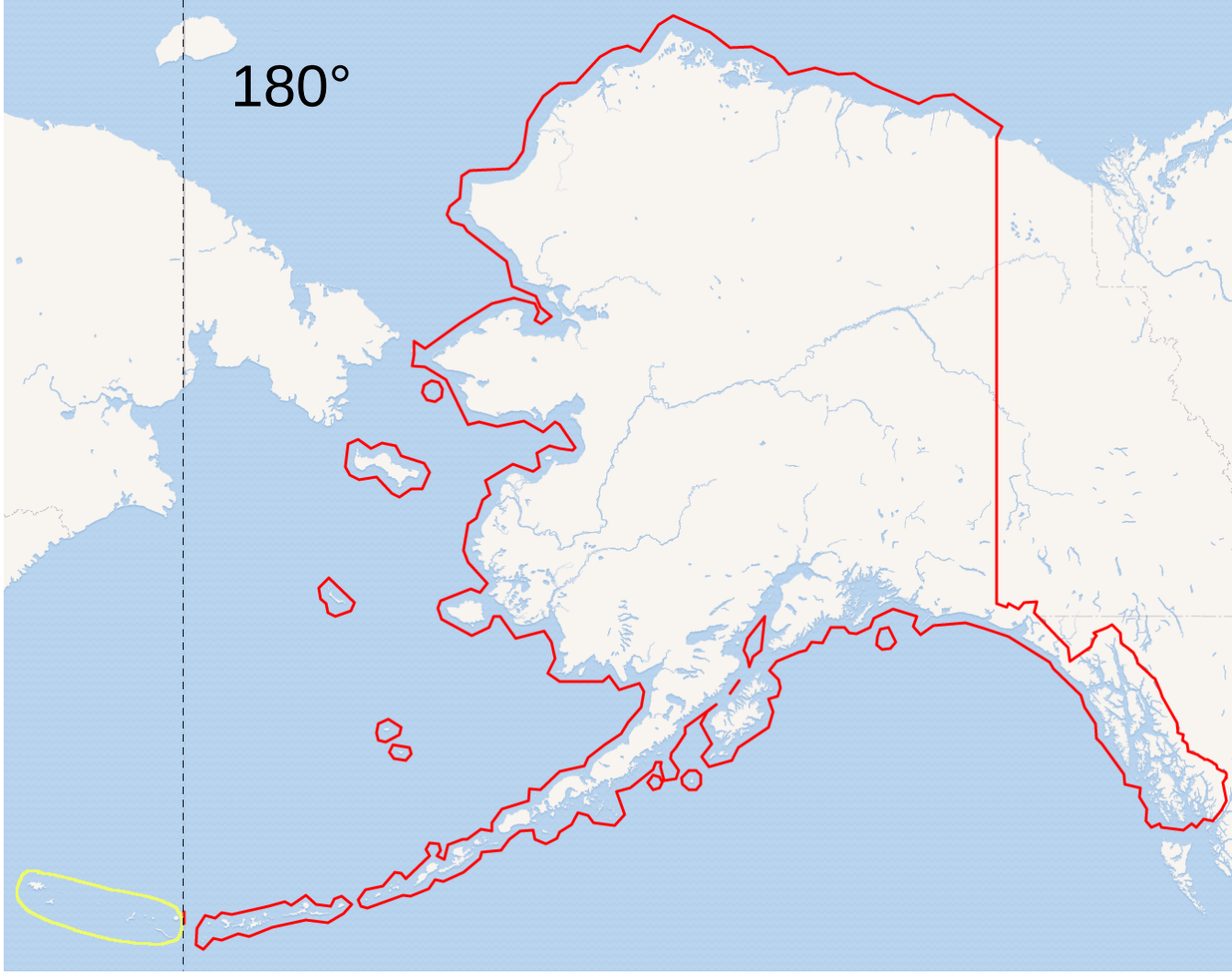
healthcare:speciality=psychiatry

Traverse City State Hospital, Michigan. Source: wikipedia

What’s the easternmost state of the US?

Alaska

- Easternmost state in the US
  - Fun fact (unless you are a programmer)
  - Breaks some geospatial libraries



Source: wikipedia, OSM

Limitations

- Accuracy of amenity=hospital is unknown
  - Some clinics are tagged as hospitals
- Doesn’t reflect specific services
- Doesn’t consider traffic

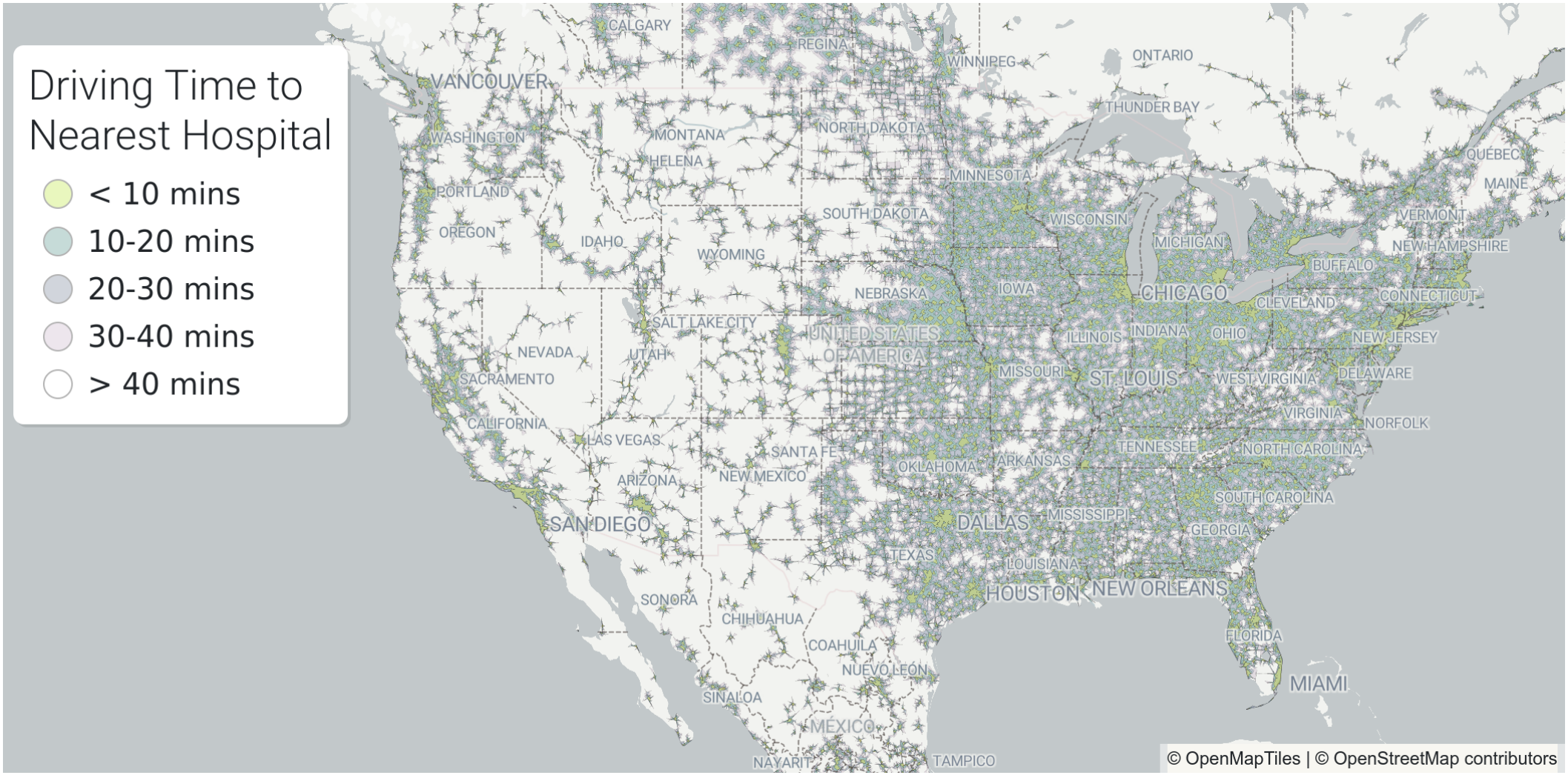
Future Work

- Use a different dataset for hospitals (DHS HIFLD)
- Use a dataset of services offered by each hospital
  - dolthub’s CMS pricing dataset

Visualizing the Results

- Entirely open source tools
- Cost effective hosting options (100% serverless)
- Two layers:
  - Greyscale base map showing major features
  - Isochrones layer to display on top
    - Based on Viridis color scheme

Demo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> 40 mins
CALGARY
REGINA
WINNIPEG
ONTARIO
VANCOUVER
THUNDER BAY
WASHINGTON
MONTANA
NORTH DAKOTA
HELENA
QUÉBEC
MINNESOTA
MAINE
PORTLAND
SOUTH DAKOTA
WISCONSIN
VERMONT
OREGON
IDAHO
MICHIGAN
NEW HAMPSHIRE
WYOMING
BUFFALO
NEBRASKA
IOWA
CHICAGO
CONNECTICUT
CLEVELAND
SALT LAKE CITY
UNITED STATES
ILLINOIS
INDIANA
OHIO
NEW JERSEY
NEVADA
UTAH
OF AMERICA
MISSOURI
ST. LOUIS
WEST VIRGINIA
DELAWARE
SACRAMENTO
VIRGINIA
CALIFORNIA
NORFOLK
LAS VEGAS
TENNESSEE
NORTH CAROLINA
SANTA FE
OKLAHOMA
ARKANSAS
NEW MEXICO
ARIZONA
SOUTH CAROLINA
SAN DIEGO
DALLAS
MISSISSIPPI
GEORGIA
TEXAS
LOUISIANA
HOUSTON
NEW ORLEANS
SONORA
CHIHUAHUA
FLORIDA
COAHUILA
NUEVO LEÓN
MIAMI
SINALOA
MEXICO
NAYARIT
TAMPICO
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MapLibreGL

- Provides a “slippy map” based on vector tiles
- Open source fork of Mapbox GL JS
- Lots of customization options for styling

ProtoMaps

- Serverless system for retrieving vector map tiles from a single file
- Uses HTTP Range requests to retrieve the relevant subset of data from the file
  - Similar to video seeking over HTTP

Other tools

- Planetiler – used to generate the vector tiles from OSM PBF
- Tippecanoe – used to generate vector tiles from the isochrone GeoJSON

Hosting

- Total data size for VA map:
  - 1.3MB for base map layer of VA
  - 11MB for isochrone layer
- North America map:
  - < 1GB
  - Cloudflare R2 for hosting the data

Conclusion

- These tools can be used to lower the cost of map-based visualization by orders of magnitude
- OSM tooling adopted by:
  - NYT, Washington Post

For more details and interactive visualizations

https://wcedmisten.fyi

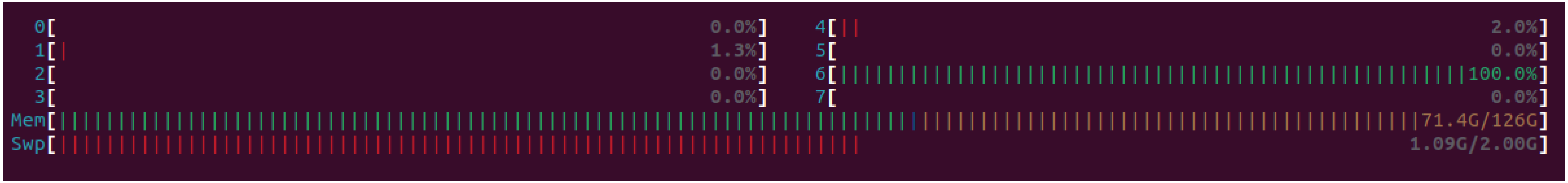
Appendix

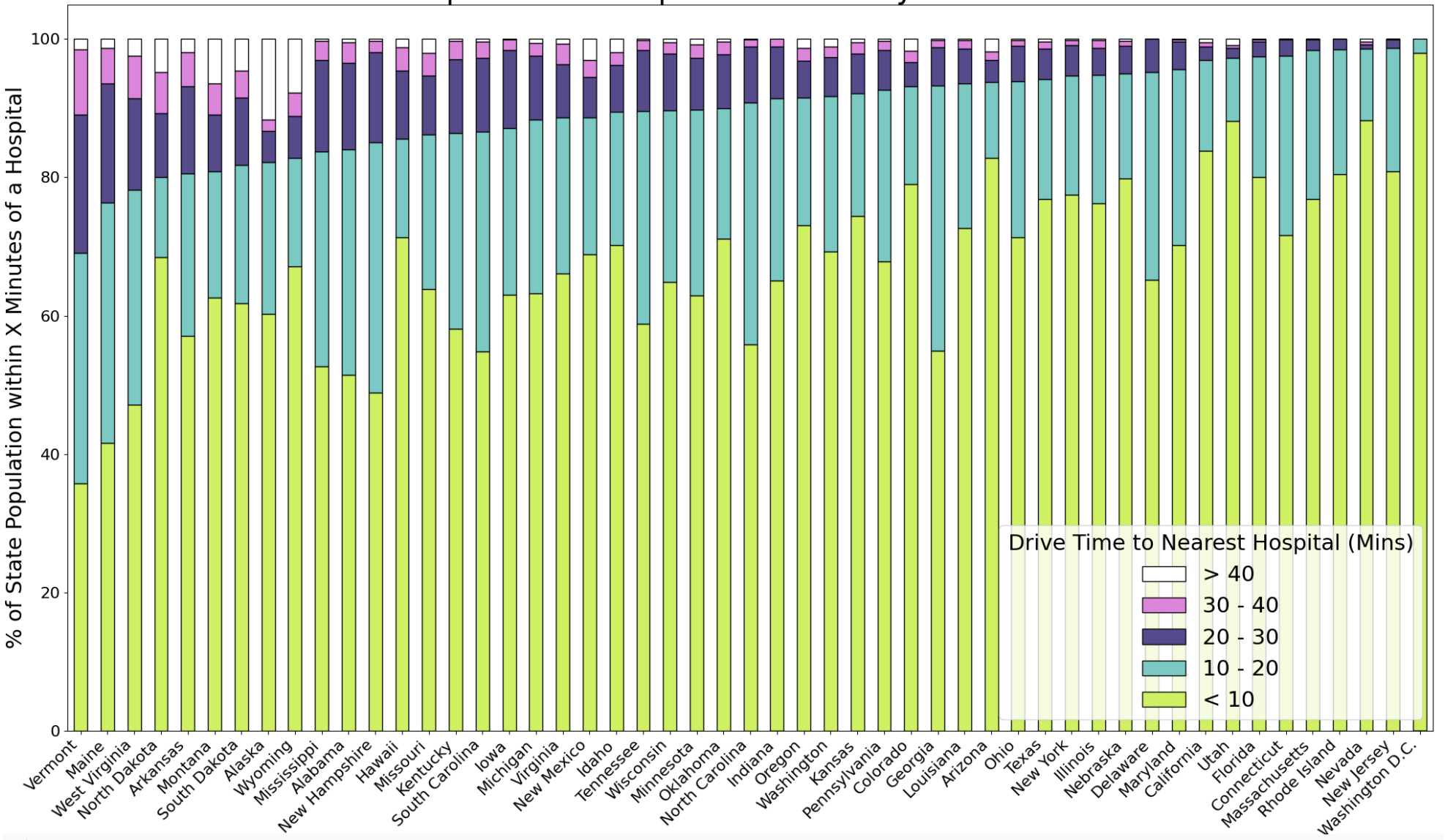
Link to Project

https://wcedmisten.fyi/project/north-america-hospital-distance/

Hardware

- Calculating union of 12,000 polygons spanning North America… takes lots of RAM
- CPU: i7-10700K
- 128 GB RAM
- 4 TB SSD

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New Mexico
Idaho
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Oklahoma
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Washington
Kansas
Pennsylvania
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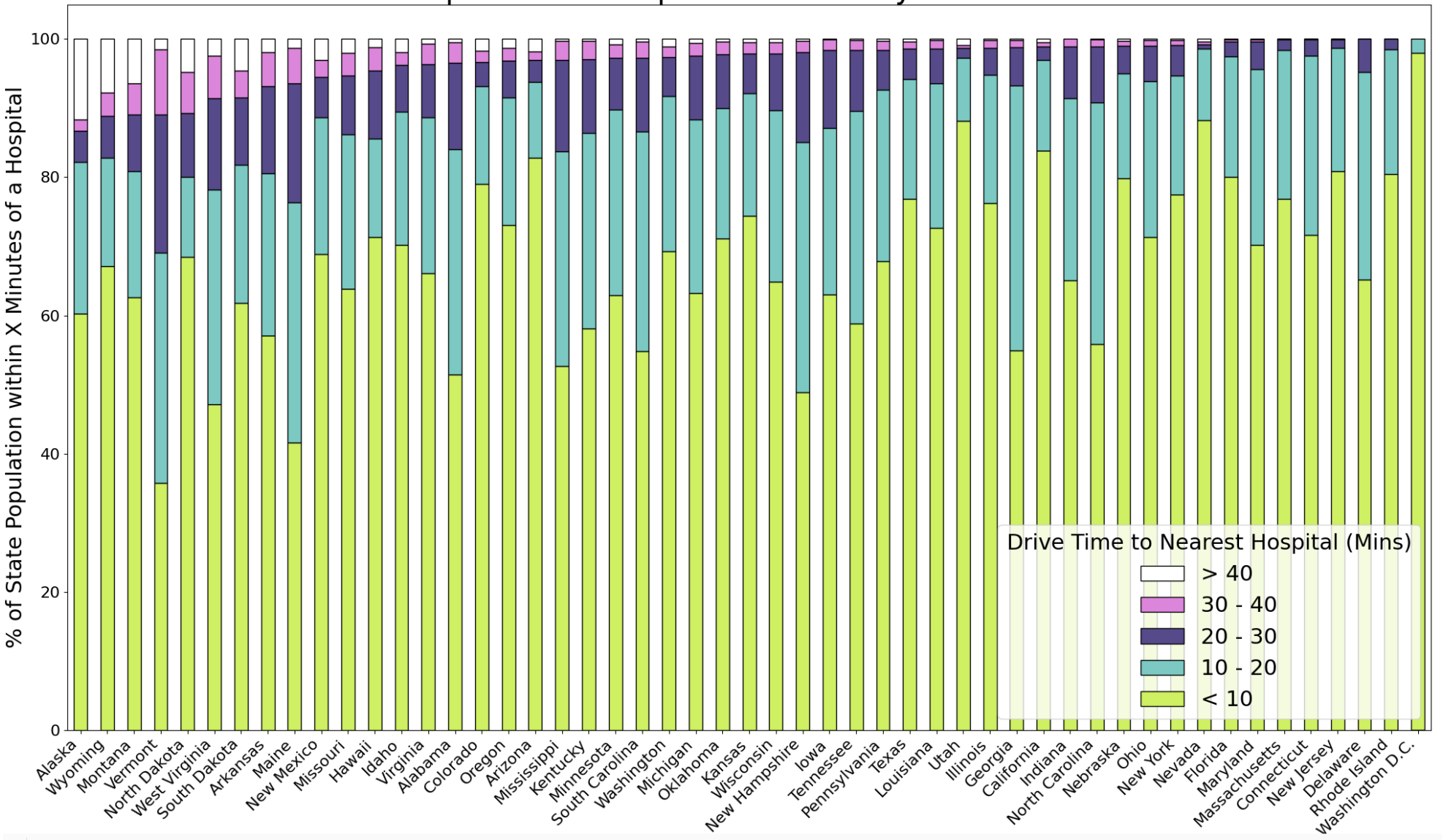
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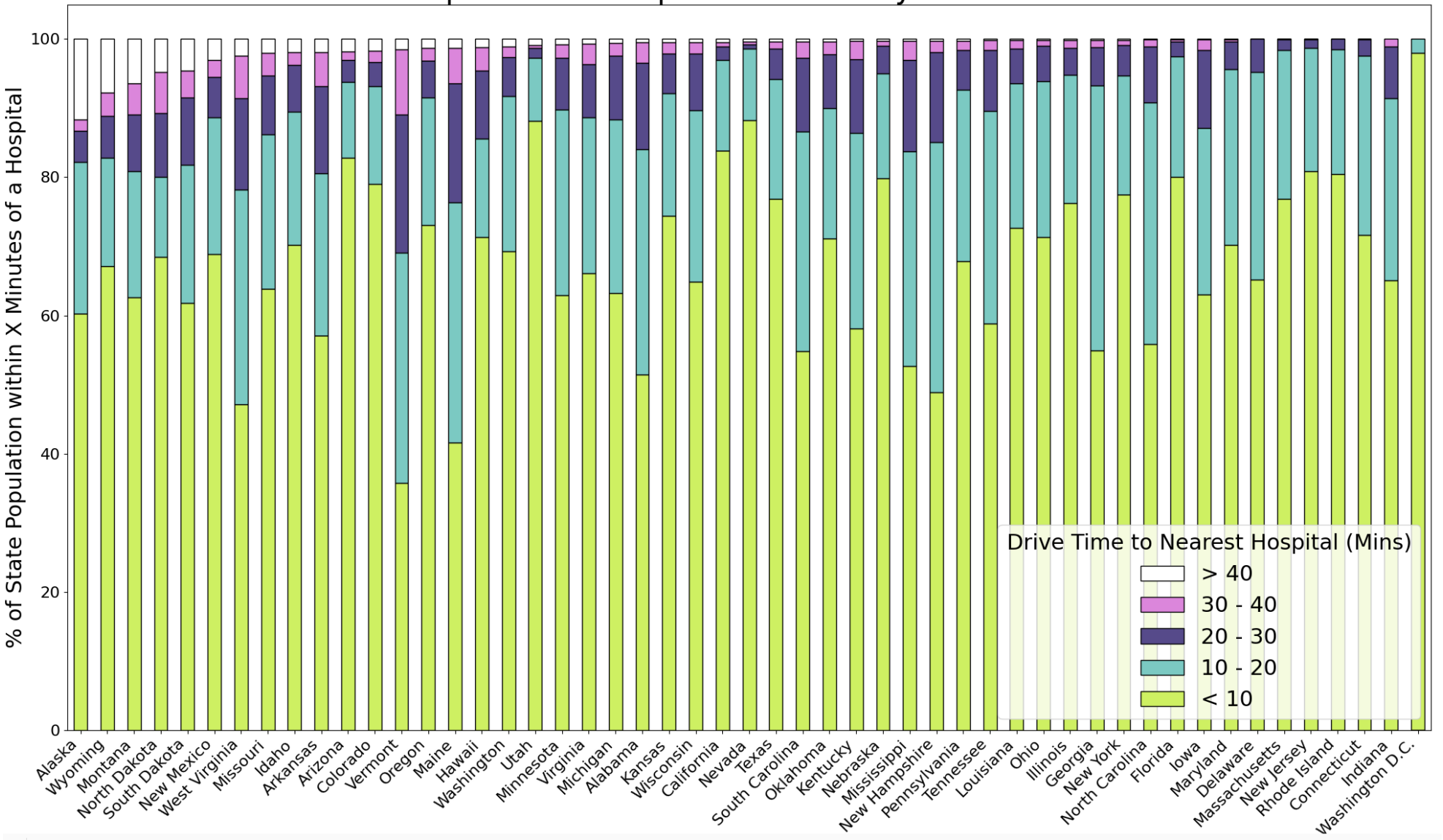
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Pennsylvania
Tennessee
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