

Lab: Spatial Accessibility of Hospitals in Vermont

PURPOSE

Vermont was just awarded a **\$195 million** grant for **rural health care transformation!**

<https://vtdigger.org/2025/12/30/vermont-receives-195m-federal-grant-for-rural-health-care-transformation/>

As part of the grant, we have been recruited to use spatial analysis to evaluate the efficiency and accessibility of Vermont's hospital system. We will start by answering three questions about hospital service areas and accessibility:

- 1) Where in Vermont are the Dartmouth HSAs smaller than the catchment areas predicted by central place theory. The answer may suggest possible service inefficiencies.
Find this by visually comparing/overlaying Dartmouth HSA polygons to polygons constructed from hospital points based on central place theory.
- 2) How many residential locations in each Dartmouth HSA are outside of 30 minutes driving time of a hospital, and what is the percentage? The answer may identify service gaps to inaccessible locations.
- 3) On a town by town basis, what is the mean center of residential locations outside of 30 minutes driving time of a hospital. The answer may suggest possible locations for investing in mobile rural health and rescue services.

OUTCOMES

The outcome for **part 1** should be two polygon layers symbolized so that they can be seen visualized simultaneously and compared.

The outcome for **part 2** should be a choropleth map of hospital service area polygons, derived from an attribute table containing the following data fields:

- Total Residential Locations
- Residential Locations without Access
- Residential Locations without access (percent)

The HSAs with the most total inaccessible locations are shown below:

<u>HSA</u>	<u>Residential Locations</u>	<u>Accessible Locations</u>	<u>Inaccessible Locations</u>	<u>Inaccessible Locations (%)</u>
St Albans	19,761	15,155	4,606	23.31
Bennington	18,568	15,133	3,435	18.50
Newport	11,657	8,678	2,979	25.56
Springfield	16,484	13,953	2,531	15.35
Rutland	26,732	24,593	2,139	8.00

The outcome for **part 3** should be a map of mean coordinates for each town that has residential locations lacking access to a hospital. There should be **100 points**.

Bonus: can you also summarize the total number of residential locations lacking access by town, so that you can use proportional symbols to visualize them?

METHODS

Consider the following hints and methodological decisions in your workflow:

- “Residential locations”** can be conceptualized as one residence per each e911 point location of a residential type, e.g. single-family home, mobile home, residential farm, etc. The provided `e911_residential` data contains only residential locations.
- We may consider e911 locations to be accessible to a hospital if they are inside a 30-minute service area defined as the smallest possible polygon surrounding all the road segments within 30 minutes driving time of any hospital. For this analysis, we **do not** need to buffer either the roads or the network results. The computational expense of doing so is greater than the benefit.

DATA

All data sources are provided as layers within the `vermont_hospitals` geopackage database.

`dartmouth_atlas_hsa`

- **Title:** Hospital Service Areas
- **Responsible party:** The Dartmouth Atlas Project in The Dartmouth Institute for Health Policy and Clinical Practice
- **Spatial Coverage:** United States (covers 50 states, does not include other territories).
- **Coordinate Reference System:** EPSG:4269 NAD83 geographic coordinate system.
- **Spatial Resolution:** Zip code tabulation areas, possibly with some line simplification
- **Spatial Representation Type:** Multi-polygons
- **Temporal Coverage:** The range of dates of patient data is not readily transparent based on documentation. More specific documentation is needed from the data providers on this point. The latest vintage of data is ca. 2024.
- **Lineage:** Data originally accessed from the Dartmouth Health Atlas on 4/30/2024. Each hospital region is constructed of zip code tabulation areas (zctas), assigning each ZCTA to the hospital the majority of patients in each zip code attended, according to Medicare data.
- **Distribution:** Available at <https://data.dartmouthatlas.org/supplemental/#boundaries>.
- **Constraints:** Open access. See terms of use: <https://data.dartmouthatlas.org/terms-of-use/>.
- **Variables:**
 - **HSA93** (*integer*): unique identifier for each health service area.
 - **HSANAME** (*text*): unique name for each Hospital Service Area, roughly equivalent to the town and state in which the hospital is located.
 - **HSA_label** (*text*): unique name for each Hospital Service Area, roughly equivalent to the town or city in which the hospital is located.

`e911_residential`

- **Title:** 911 emergency point locations for residential buildings in Vermont
- **Responsible Party:** VT Center for Geographic Information
- **Spatial Coverage:** Vermont
- **Coordinate Reference System:** EPSG:32145 NAD83 / VT projected coordinate system.
- **Spatial Resolution:** Precise to specific building locations
- **Spatial Representation Type:** Points
- **Temporal Coverage:** Last updated Apr 25, 2024.
- **Lineage:** Original dataset, E911 Site Locations, accessed from the Vermont Center for Geographic Information. Filtered for residential sites (see variable SITETYPE). Derrick Burt extracted all residential site types from the full E911 dataset. Non-residential site types are not included, and all features in this dataset can be considered residential.
- **Distribution:** Current version of original dataset available at VCI Open Geodata portal: <https://geodata.vermont.gov/datasets/VCGI::vt-data-e911-site-locations-address-points-1/about>.
- **Constraints:** Open access.
- **Variables:**
 - **TOWNNAME** (nominal text): the name of the town to which the location belongs.
 - **SITETYPE** (categorical text): the type of residential unit. Includes values: 'COMMERCIAL W/RESIDENCE', 'CONDOMINIUM', 'INSTITUTIONAL RESIDENCE / DORM / BARRACKS', 'MOBILE HOME', 'MULTI-FAMILY DWELLING', 'OTHER RESIDENTIAL', 'RESIDENTIAL FARM', 'SEASONAL HOME', 'SINGLE FAMILY DWELLING'

`hospitals`

- **Title:** Hospital locations in and near Vermont
- **Responsible Parties:** Department of Homeland Security
- **Spatial Coverage:** Vermont and its adjacent health service areas.

- **Coordinate Reference System:** EPSG:32145 NAD83 / VT projected coordinate system.
- **Spatial Representation Type:** Points
- **Spatial Resolution:** One point per cluster of hospital facilities at the centroid
- **Temporal Coverage:** data was accurate as of 2020
- **Lineage:** Data originally accessed from the Department of Homeland Security. Where several hospitals form a medical center, they have been aggregated together and the number of beds added together.
- **Distribution:** The data was available with a public use license from HIFLD Open Data portal before the U.S. Government shut it down in September 2025.
- **Constraints:** None. Distributor assumes no liability for misuse of data.
- **Variables:**
 - **sumBEDS** (*decimal*): the number of beds in the hospital cluster
 - **cityState** (*text*): the city of the hospital's address combined with the two-letter state code of the hospital's address, e.g. the UVM Medical Center has the value "BURLINGTON VT" and Porter Medical Center has the value "MIDDLEBURY VT"

roads

- **Title:** Roads in Vermont and surrounding areas
- **Spatial Coverage:** Vermont and its adjacent health service areas.
- **Coordinate Reference System:** EPSG:32145 NAD83 / VT projected coordinate system.
- **Spatial Resolution:** Road lines are topologically accurate within 1 meter.
- **Spatial Representation Type:** Lines
- **Temporal Coverage:** This dataset is several years old with unknown date.
- **Lineage:** Dr. Holler processed the dataset to clip to a buffered region around Vermont, fix topology errors, and improve accuracy of connectivity for highway overpasses. Derrick Burt clipped the dataset to VT and adjacent hospital service areas and deleted extraneous fields.
- **Distribution:** Data is now available through GEOG 0261 data downloads and was originally distributed by ESRI through ArcGIS Online for licensed users.
- **Constraints:** Not permissible for public redistribution outside of the Middlebury College organization.
- **Variables:**
 - **SPEED** (*integer*): speed limit measured in miles per hour
 - **ROADCLASS** (*integer*): with values
 - 1 for limited access highway
 - 2 for secondary highway
 - 3, 4, 5, and 7 for minor roads
 - 6 for entrance/exit ramps or roundabouts (traffic circles)
 - **speedKM** (*decimal*): speed, converted to kilometers per hour. Speeds of 15mph or less were converted to 15mph before conversion. Calculated as:

```

CASE
WHEN "SPEED" >=15 THEN "SPEED" * 1.60934
ELSE 15* 1.60934
END

```

Vermont

- Just a polygon of the state of Vermont in the EPSG:32145 NAD83 / VT projected coordinate system

AM I DONE?

Check the following Central Falls results with an instructor:

- Visualization of Dartmouth HSAs *vis a vis* central place theory
- Percentage of residential locations without access to hospitals per Dartmouth HSAs
- Mean center of residential locations without access to hospitals per town

Consider backing up your whole GEOG261 folder to an external drive or cloud storage service of your choice!

INTERPRETATION

Part 1: Comparing Dartmouth HSAs to central place theory

Keep in mind that Dartmouth HSA boundaries delineate the geographic regions in which the majority of patients (Medicaid and Medicare, specifically) actually use hospital services. The regions are based on observed human behavior.

There are at least a few different reasons why the Dartmouth HSA boundaries contradict central place theory. Ex

amine different cases closely to try to identify some of these reasons.

Parts 2 and 3: Hospital Service Area Gaps

The trend in the United States is to reduce services in small market and rural hospitals, downgrade hospitals to urgent care centers, or close hospitals all together. Given what you observe in our analysis of inaccessible residential locations...

Are there any hospitals that could close without substantially impacting access? Which ones?

What are the weakest links in Vermont's hospital system?

Which rural hospital closures might create the most severe access gaps?

What recommendations could you make to expand access?