Distance Gained is Brain Lost:

Visualizing the Distribution of Stroke Fatalities and Access to Intravenous Alteplase in Vermont, 2016

Background

Stroke is the 5th leading cause of death in the United States (Congress, CDC, & Heron PhD, 2018) and the leading cause of disability (Association, 2019). A stroke is a blood clot or blood vessel rupture in the brain that leads to decreased oxygen flow and ultimately brain cell deterioration or death. As soon as the stroke occurs, time is of the essence. The longer an area of the brain endures limited oxygen supply the larger the impact of the stroke, leading to increased risk of functional disability such as paralysis, language impairment, and life-sustaining functions. It is critical that an individual having a stroke gets case as soon as symptoms begin.

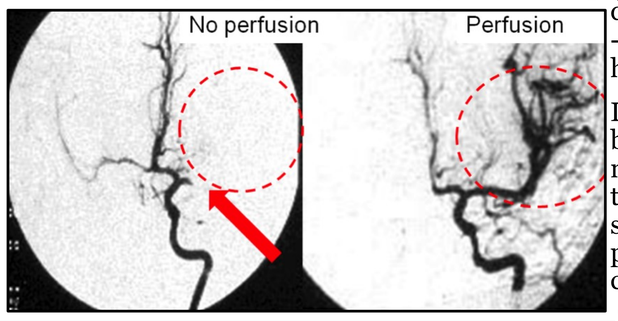


Figure 1. Before and after IV tPA administration. The red arrow indicates the location of the stroke where blood flow was restricted. After tPA, blood flow has been restored.

Ischemic stroke, or a clot occluding a blood vessel in the brain, is the most common type of stroke, accounting for nearly 87% of all strokes (CDC). Advances in drug therapies as well as neuro-interventional radiology have significantly improved stroke outcomes for patients who present quickly to care (Powers et al., 2018). One therapy called Intravenous Alteplase, also known as IV tPA, is a clot-busting drug that decreases both stroke mortality and morbidity (Powers et al., 2018). Because of its strength, IV tPA can only be administered to patients who present to a hospital within 4.5 hours since last seen well and is most effective for those who receive it within 3 hours of last known well (Powers et al., 2018).

The American Stroke Association developed a campaign in 2010 called *Target Stroke* to improve stroke systems of care within the clinical setting. Part of this initiative is to ensure all ischemic stroke patients eligible to receive IV tPA do so within 60 minutes of arriving to the hospital (Target Stroke). This goal, in combination with the clinical guidelines of administering IV tPA within 3 hours of last known well, only gives a patient 2 hours to arrive at a hospital after their clot has started.

Hospitals must be certified by their state Department of Health or the Joint Commission to be able to give IV tPA. Of Vermont's 15 major hospitals, only one hospital, the University of Vermont Medical Center, is certified (Commission, 2018). This leaves residents in rural parts of the state with limited access to advanced stroke care. In 2016, stroke was the 6th leading cause of death in the state of Vermont with a crude death rate of 39.5 per 100,000 (Health, 2018). With high mortality rates and low access to care, people who life further away from UVM Medical Center are less likely to get timely stroke care that could ultimately be life-saving.

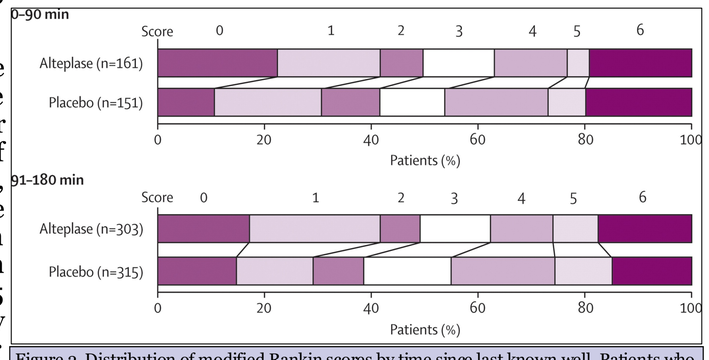
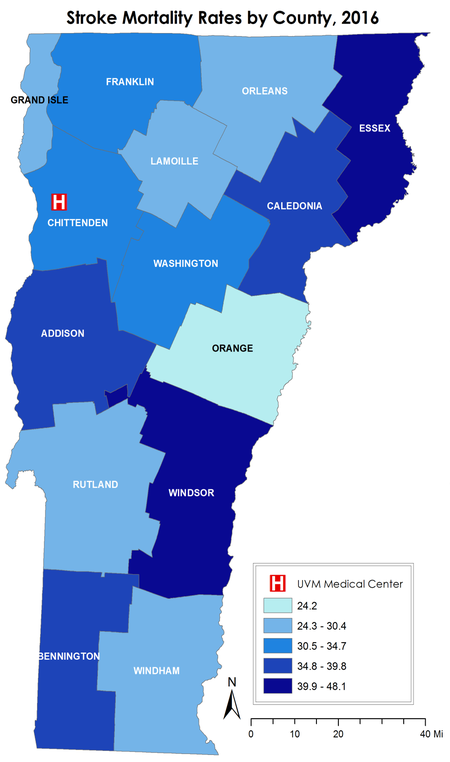


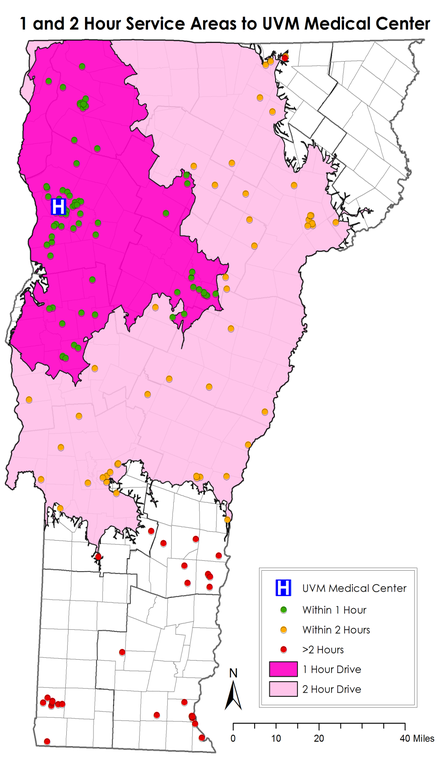
Figure 2. Distribution of modified Rankin scores by time since last known well. Patients who received IV tPA were less likely to be functionally disabled (mRS 3-5) or dead (6) 90 days post-discharge than those who received placebo (Lees et al. 2010).

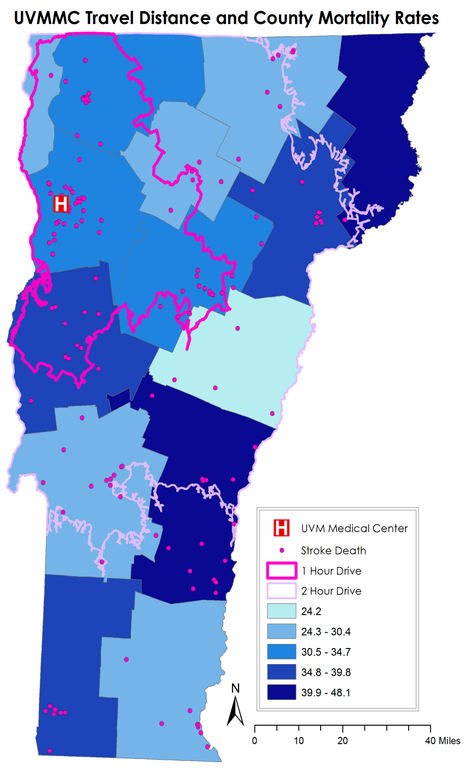
The goal of this project is to integrate address-level stroke mortalities, transit time data, health center data, and maps of Vermont to visualize vulnerable areas of the state that lack access to advanced stroke care. This research intends to discover spatial patterns in stroke mortality data that could be used to advocate for increased access to advanced stroke care in Vermont.

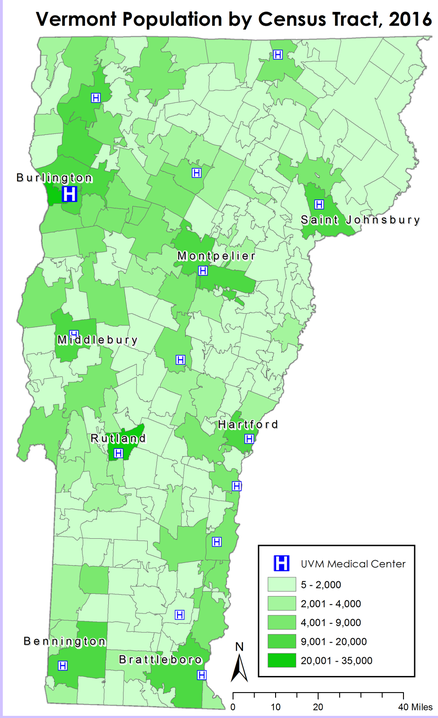
Results

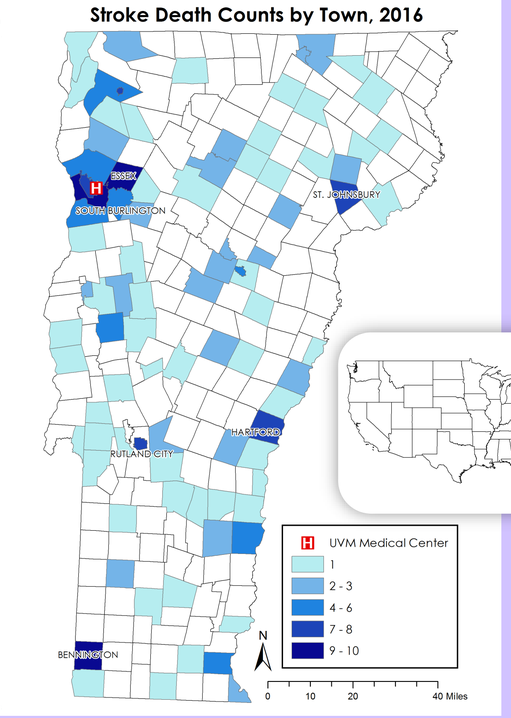
Of the 159 geocoded stroke fatalities, 52% lived within 1 hour of UVMMC (82/159), 30% lived within 1-2 hours (48/159), and 18% lived further than a 2-hour drive time (29/159). The towns with the highest stroke death counts were South Burlington (10), Essex (10), Bennington (9), Burlington (8), and Hartford (8). Due to low counts, stroke mortality rates were calculated at the county level. Two counties had stroke mortality rates above the 2016 national crude rate of 44.0 per 100,000: Essex County (48.1), and Windsor County (45.3). Both Essex and Windsor County are further than a one hour drive, and only about half of Windsor county has access to UVM within 2 hours.











Methods

Address-level resident stroke mortality data was obtained from the Vital Records unit of Vermont DPH for the most recent completed year (2016). Data was cleaned in Excel, imported into ArcGIS, and geocoded. 51 of the original death records were omitted during geocoding due to insufficient address data, leaving 159 to be successfully geocoded. The geocoded addresses were exported as a shapefile and layered on top of the 2019 VT Data - State Boundary shapefile obtained from the Vermont Open Geodata Portal (VOGP).

Stroke counts (210 total) were summarized on the town level and joined to the 2019 VT Data – Town Boundaries shapefile from VOGP. These counts were then symbolized by quantity and displayed in the choropleth map titled *Stroke Death Counts by Town, 2016*.

County population estimates were obtained from the US Census Bureau as an xls file and joined to the 2019 VT Data – County Boundaries shapefile from VOGP. Stroke counts were then summarized on the county level and joined to this same shapefile. To generate county stroke mortality rates, a new variable *StrokeRate* was created by the following equation: (100,000/*CountyPop*)**StrokeCount*. Rates were symbolized by quantity and shown in the choropleth map *Stroke Mortality Rates by County, 2016*.

The hospital locations sites shapefile was obtained from VOGP and a layer to only show UVM Medical Center was created to emphasize the location of IV tPA administration. A national street network database from ESRI was then clipped to the state of Vermont, and a service network analysis was conducted to visualize 1- and 2-hour drive networks towards UVM Medical Center. Geocoded stroke mortalities were overlaid to then visualize the distribution of fatalities in relation to hospital proximity, seen in *1 and 2 Hour Service Areas to UVM Medical Center*.

Discussion

By count alone, nearly one fifth of Vermont's fatal stroke population did not have access to IV tPA within a 2-hour drive. Counties with higher mortality rates also appeared further from UVM Medical Center; including Essex, Windsor, Bennington, and Caledonia Counties, suggesting gaps in access in these regions.

This research showed strength in the visualization of 1- and 2-hour drives in the network analysis map to better understand areas of the state that lack access to advanced stroke care. However, for patients who live within a 2-hour drive, many factors such as comorbidities, age, location of the clot in the brain, as well as behavioral habits may exclude them from being able to get IV tPA. Additionally, these patients are not guaranteed to arrive within the IV tPA administration window. This combination of factors suggests that living within a 2-hour drive is not sufficient enough to guarantee access to advanced stroke care.

One limitation of this research is that the stroke mortality data obtained from Vital Records does not differentiate between ischemic and hemorrhagic stroke deaths. Additionally, deaths were based on an individual's residence rather than place of death.

Overall, distance to advanced care is an important barrier to consider when thinking about stroke prognosis. Future research in Vermont should consider adding resources to reduce the impact distance may play in rural stroke outcomes.

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