Modeling Optimal Treatment Decisions for Large Vessel Occlusion in Acute Stroke Patients

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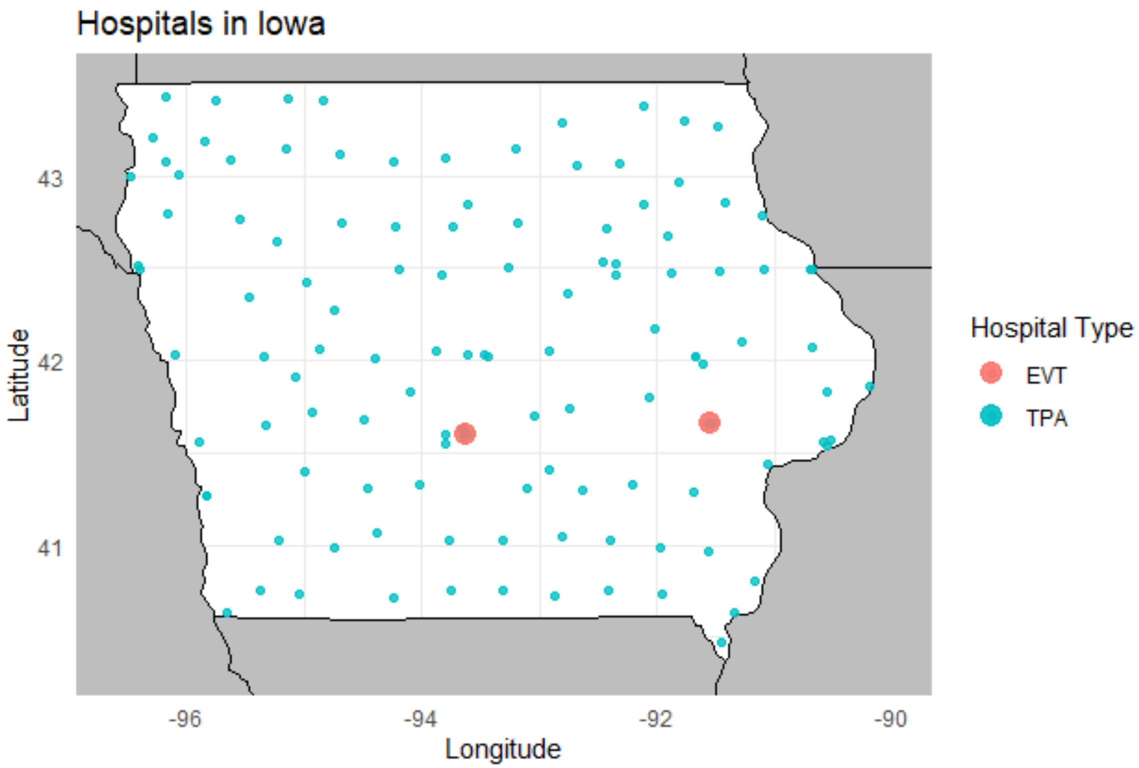
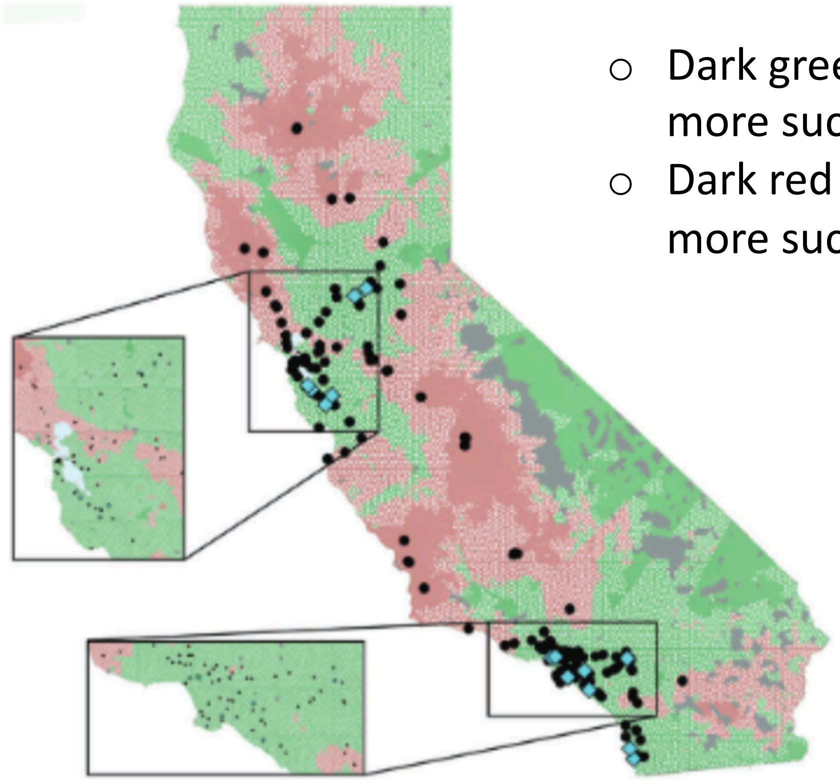
Research Question

- Patients suffering from large vessel occlusion (LVO) in acute stroke have two treatment courses available
  - **TPA**; Receive medication at local hospital, transfer to EVT center for surgery
  - **EVT**; transfer straight to EVT center for surgery
- Time sensitive decisions must be made in the field by EMTs
- **Based on the distance from the LVO event to the closest TPA & EVT hospitals, which hospital and treatment plan will result in the best outcome for the patient?**



Prior Research

- Two prior studies:
  - Modeling Stroke Patient Transport for All Patients With Suspected Large-Vessel Occlusion
    - Dr. Jessalyn Holodinsky
  - Association Between Time to Treatment With Endovascular Reperfusion Therapy and Outcomes in Patients With Acute Ischemic Stroke Treated in Clinical Practice
    - Dr. Reza Jehan



- Dark green = EVT more successful
- Dark red = TPA more successful

Holodinsky et al., 2018

Data

- Simulated data for 600 patients across Iowa
- Variables
  - Onset to treatment time (**OTT**) in minutes
  - **Transfer time** from TPA hospital to EVT hospital in minutes
  - Indicator variables to identify whether patient received
    - **TPA** then transfer to EVT
    - **EVT** directly
  - "Excellent" Outcome

Bayesian Statistics

- Likelihood function
  - Y ~ Bernoulli(π)
- Prior distribution
  - βi ~ normal(0,10)
- Posterior distribution
- rstan package in R

$$\underbrace{P(A|B)}_{\text{Posterior}} = \frac{\overbrace{P(B|A)}^{\text{Likelihood}} \cdot \overbrace{P(A)}^{\text{Prior}}}{P(B)}$$

Logistic Regression Model

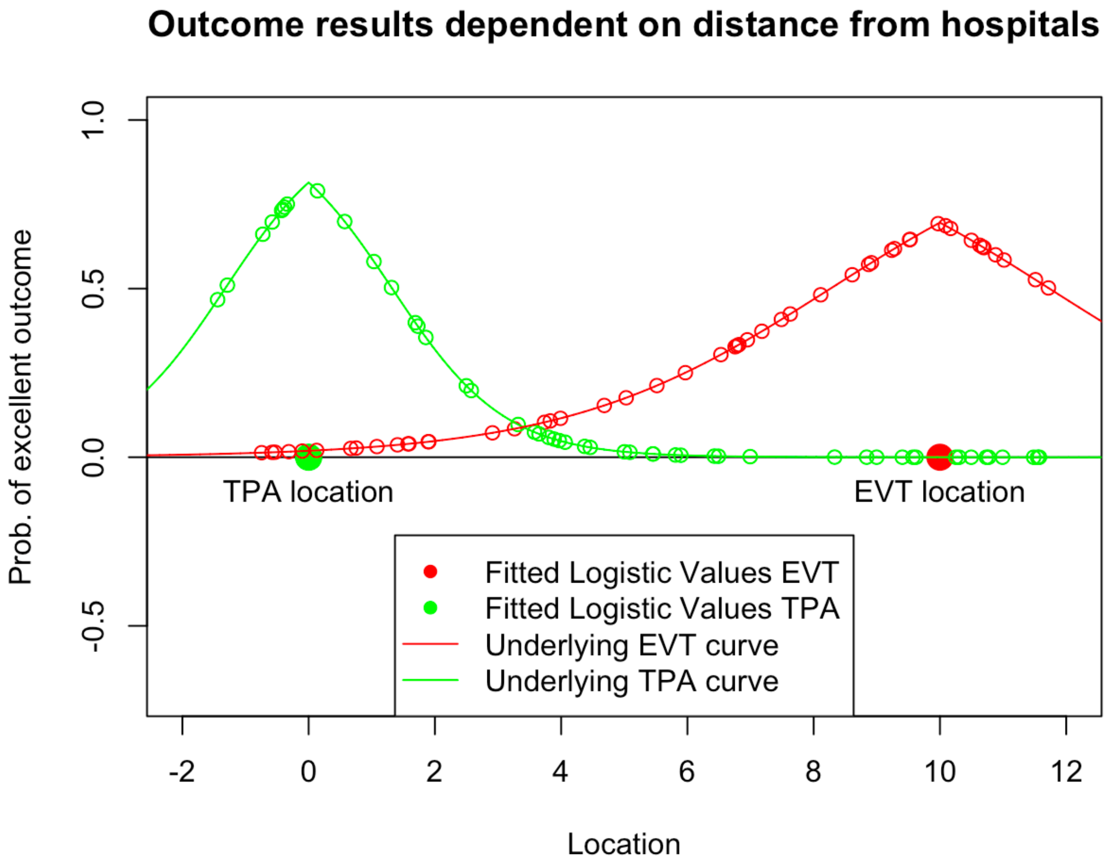
$$\eta = \beta_0 + \beta_1 EVT + \beta_2 EVT * OTT + \beta_3 TPA * OTT + \beta_4 TPA * TransferTime$$

$$\pi = \frac{e^{\eta}}{1 + e^{\eta}}$$

Stan Model

```
data{
  int Nobs; // Number of observations
  int<lower=0> Y[Nobs]; // Vector of binary outcomes - 1 is excellent outcome
  real<lower=0> ott[Nobs]; // Vector of onset to treatment times
  real<lower=0> transfertime[Nobs]; // Vector of transfer times
  int<lower=0, upper=1> EVT[Nobs]; // Indicator for EVT
  int<lower=0, upper=1> TPA[Nobs]; // Indicator for TPA
}
parameters{
  real beta0; // Intercept
  real beta1; // Main effect: EVT
  real beta2; // Onset To Treatment effect for EVT
  real beta3; // OTT effect for TPA
  real beta4; // transfer time effect for TPA -> EVT
}
transformed parameters{
  real eta[Nobs];
  for (i in 1:Nobs) {
    eta[i] = beta0 + beta1*EVT[i] + beta2*EVT[i]*ott[i] + beta3*TPA[i]*ott[i] + beta4*TPA[i]*transfertime[i];
  }
}
model {
  // Vague prior distributions for the coefficients
  beta0 ~ normal(0,10);
  beta1 ~ normal(0,10);
  beta2 ~ normal(0,10);
  beta3 ~ normal(0,10);
  beta4 ~ normal(0,10);
  // Likelihood - bernouli
  for (i in 1:Nobs) {
    Y[i] ~ binomial_logit(1, eta[i]);
  }
}
```

One-Dimensional Distance Model

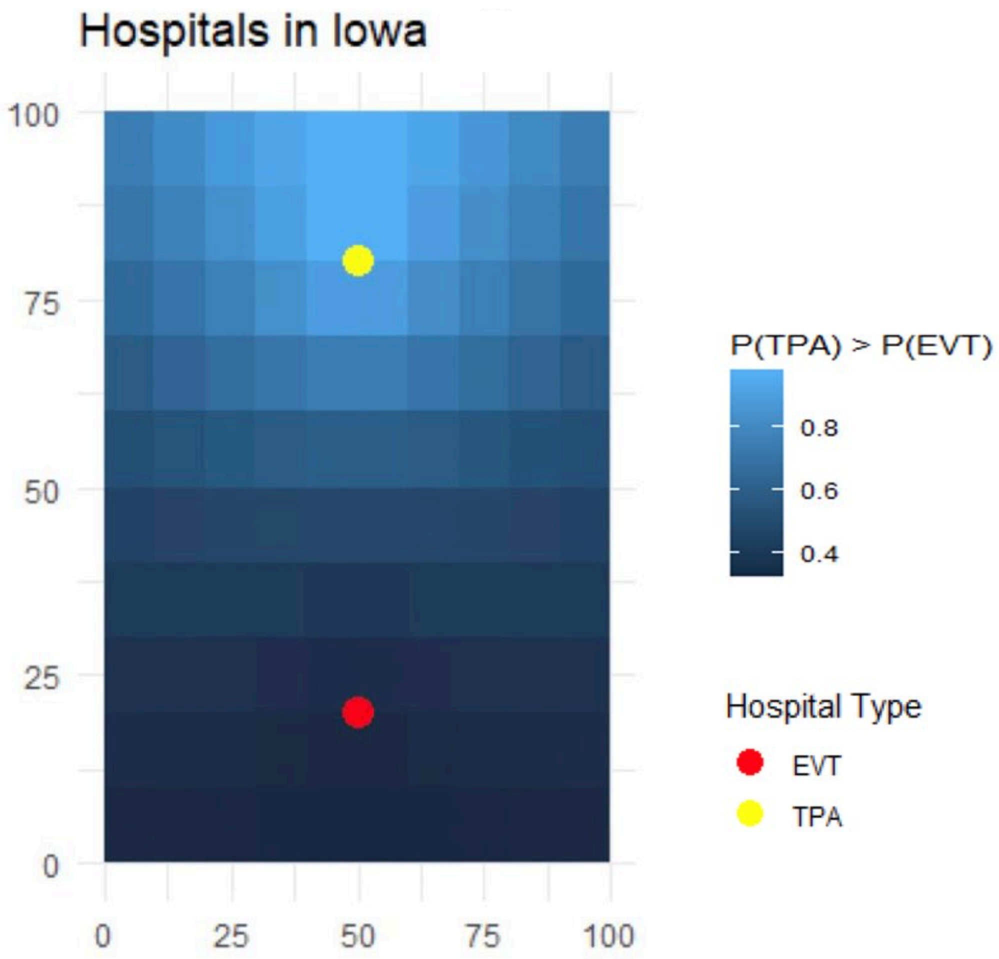


$$P(Excellent\ Outcome) = \beta_0 + \beta_1 distance\_TPA$$
$$P(Excellent\ Outcome) = \beta_0 + \beta_1 distance\_EVT$$

Two-Dimensional Distance Model

$$P(Excellent\ Outcome) = \beta_0 + \beta_1 euclidean\_distance\_TPA$$
$$P(Excellent\ Outcome) = \beta_0 + \beta_1 euclidean\_distance\_EVT$$

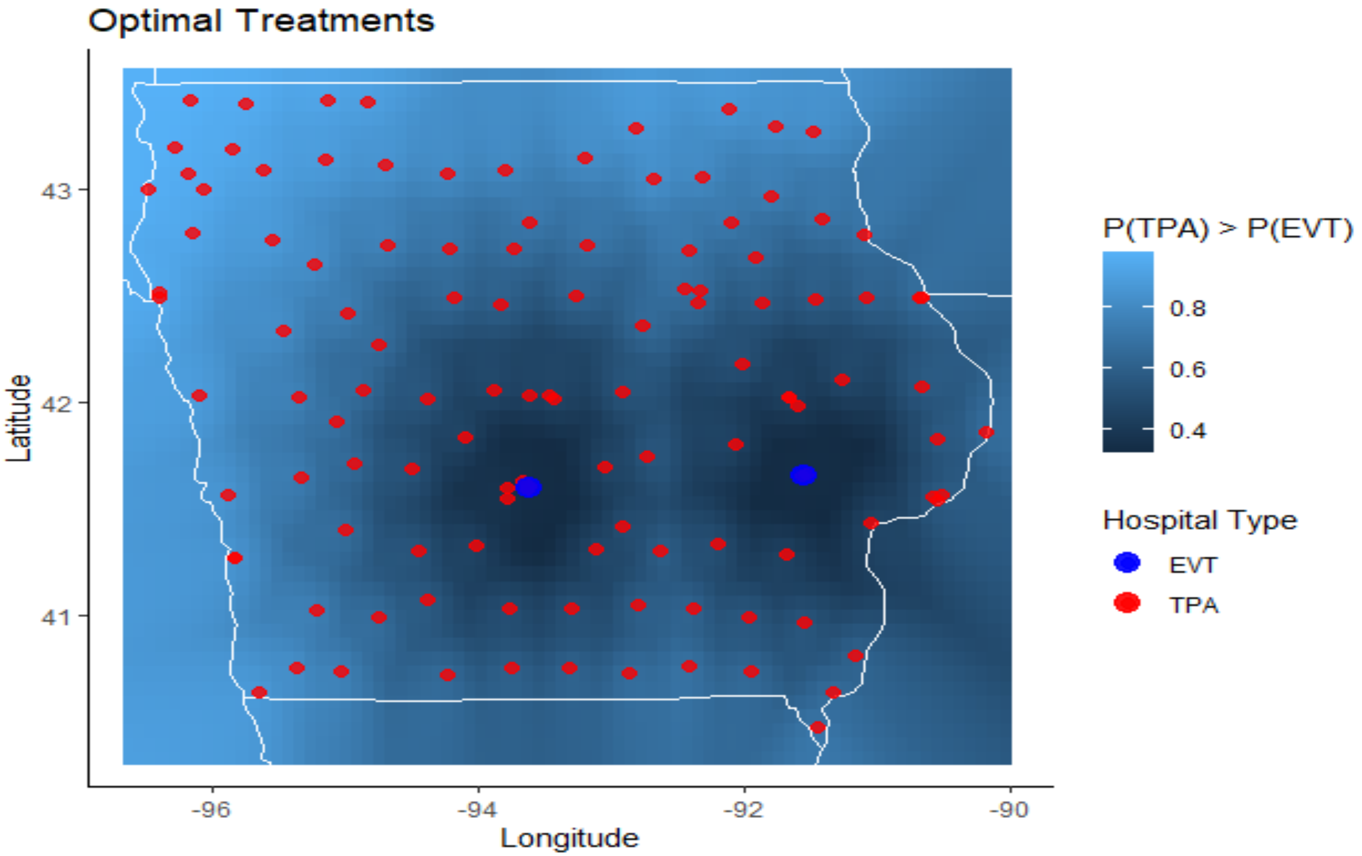
$$P(Excellent\ Outcome\ w/\ TPA\ then\ EVT) > P(Excellent\ Outcome\ w/\ EVT)$$



Full State Model

$$P(Excellent\ Outcome) = \beta_0 + \beta_1 EVT + \beta_2 EVT * OTT + \beta_3 TPA * OTT + \beta_4 TPA * TransferTime$$

$$P(TPA\ Excellent\ Outcome) > P(EVT\ Excellent\ Outcome)$$



Future Work

- Incorporating real data
- Expanding the model
  - Detecting large vessel occlusion
  - Patient demographics
  - Travel time
  - Treatment delays
- App development for EMT use

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Questions?