The differential equation has the following solution,

\[ \frac{dV(t)}{dt} + V(t) = V_0 \]

\[ r = \left( -0.0013 \cdot (220 - V_0) + \frac{11}{220} \right) + 0.0179 \]  \hspace{1cm} (60)

The state's network of stroke centers is configured within 15,811 geographic block-groups as defined by census data, and travel time from stroke onset to reperfusion for MS and DNS is computed using the centroid of each block-group as the patient pick-up location.

For each block-group, Monte-Carlo methods generate a distinct Beta distribution of LVO's and a second independently sampled Beta distribution of non-LVO's.

For each block-group and for each of MS and DNS, Eqn. (1) is applied in an LVO-only model and an all-stroke (LVO & non-LVO combined) model. The resulting distributions of evolved patient infarct volumes are translated into cumulative distribution functions of mRS via Eqn (2). Continuous mRS is used for this analysis, but using the discretized scale does not vary results significantly.

For each block-group, we compute a one-tailed, two-sample Kolmogorov-Smirnov test for statistical significance and a Cohen’s d effect size statistic for practical significance between the distributions of mRS outcomes for MS and DNS.

All model parameters, including probabilities of reperfusion dependent on treatment type, were established from large cohort studies.

Background

- Primary Stroke Center (PSC): has acute stroke imaging to identify severity of stroke and can treat non-LVO's with tPA (~70% of cases)
- Comprehensive Stroke Center (CSC): can do everything that PSC can and has resources to perform endovascular thrombectomy ( EVT) to treat large-vessel occlusions (LVO, ~30% of cases)
- Drip and Ship (DNS): if the CSC is further away than the PSC, then EST goes to the PSC. If the patient scans at PSC show an LVO, then proceed to the CSC for EVT.
- Mothership (MS): EST goes straight to the CSC, even if it is further away than the PSC.
- Bypass Time: the absolute difference between the time from patient pick-up to CSC and the time from patient pick-up to PSC.

Methods

- We represent the physiology of infarct core growth as a first-order ordinary differential equation, enabling infarct volume \( V(t) \) for a single patient to be calculated and mapped to mRS at time of reperfusion given a simulated penumbra volume \( V_p \) and collateral score \( r \) parameterized by penumbra volume\(^1\)

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Objectives

- To create a generalized, stochastic model of time-dependent acute ischemic stroke growth based on realistic physiological mechanisms.
- To apply the stochastic model in a case study of Texas to identify regions where one emergency stroke transportation (EST) method is significantly favored over another.

Results

- Of the 33,113 blocks where the PSC is the closest hospital from origin, DNS produces significantly better stroke outcomes than MS in 71.5% (1.7% std dev; \( p < 0.01; n = 15,000 \) per block-group).
- For the subset of only LVO patients, MS produces significantly better outcomes in 66.1% of blocks (0.6% std dev; \( p < 0.01; n = 4,500 \) per block-group).

Discussion

- Of the 33,113 blocks where the PSC is the closest hospital from origin, DNS produces significantly better stroke outcomes than MS in 71.5% (1.7% std dev; \( p < 0.01; n = 15,000 \) per block-group).
- For the subset of only LVO patients, MS produces significantly better outcomes in 66.1% of blocks (0.6% std dev; \( p < 0.01; n = 4,500 \) per block-group).

Figure 1. All block-groups that statistically favor MS. Effect size of MS outcomes compared to DNS outcomes (left) and odds ratio of the probability of a good outcome (mRS 0-1) of MS over the probability of good outcome of DNS colored by magnitude of effect size (right).

Figure 2. All block-groups that statistically favor DNS. Effect size of DNS outcomes compared to MS outcomes (left) and odds ratio of the probability of a good outcome (mRS 0-1) of DNS over the probability of good outcome of MS colored by magnitude of effect size (right).

Figure 3. Heat map of block-groups showing regions that statistically favor an EST method.