Modelling the Use of a New Large Vessel Occlusion Screening Tool for Ischemic Stroke Transport Decision Making in Victoria, Australia

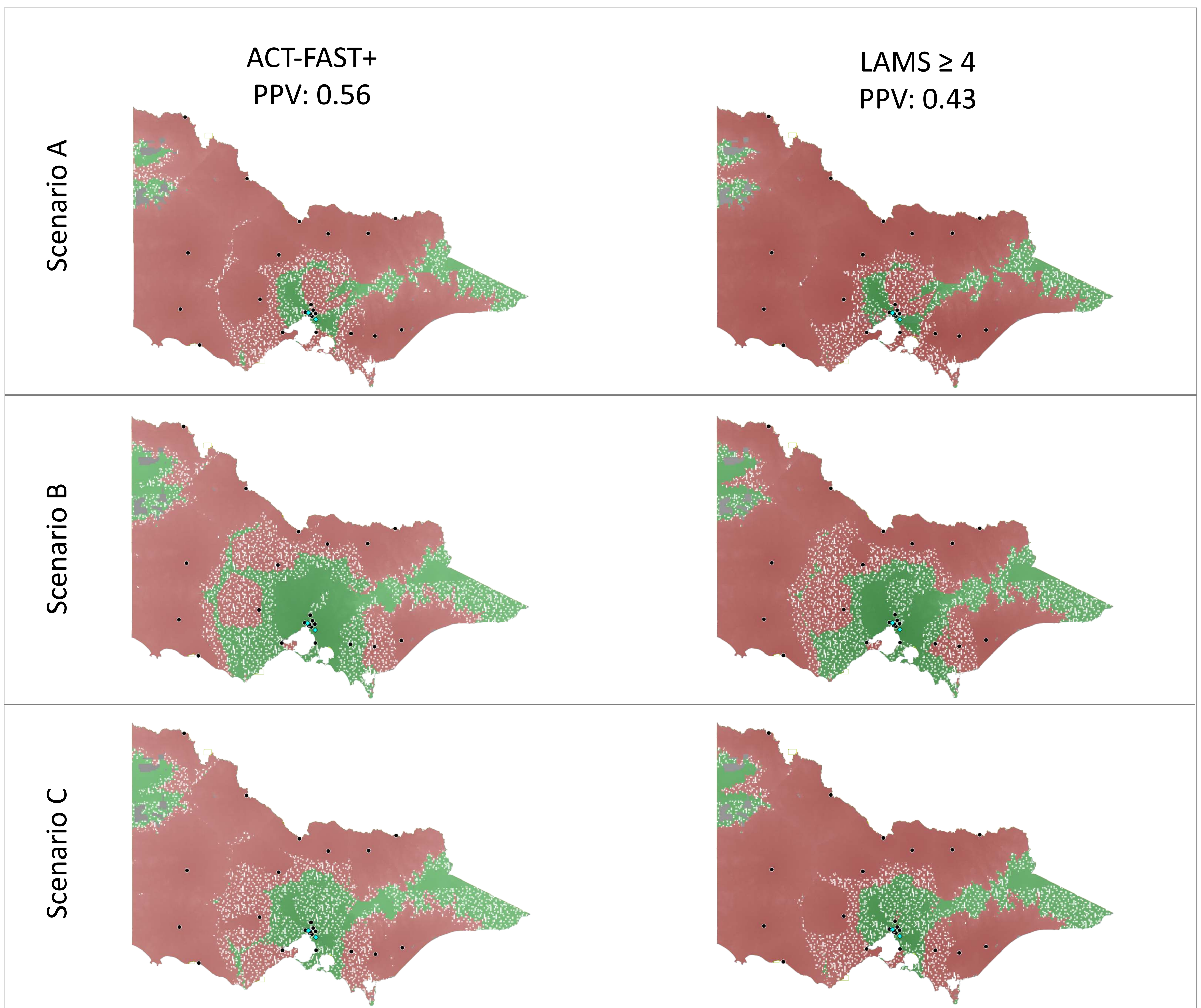
Jessalyn K. Holodinsky MSc,[1,2] Henry Zhao MBBS,[3] Michael J. Francis,[4] Luke Zhu,[5] Nawaf Yassi PhD,[3] Stephen M Davis MD PhD,[3] Bruce CV Campbell PhD,[3] Michael D. Hill MD MSc,[1,2,6-8] and Noreen Kamal PhD[5,6]
1 Department of Community Health Sciences, Cumming School of Medicine, University of Calgary, Canada, 2 Hotchkiss Brain Institute, Cumming School of Medicine, University of Calgary, Canada, 3 Melbourne Brain Center at Royal Melbourne Hospital, Department of Medicine, The University of Melbourne, 4 Department of Mechanical and Manufacturing Engineering, Schulich School of Engineering, University of Calgary, Canada, 5 Department of Electrical and Computer Engineering, Schulich School of Engineering, University of Calgary, Canada, 6 Department of Clinical Neurosciences, Cumming School of Medicine, University of Calgary, 7 Calgary Stroke Program, Cumming School of Medicine, University of Calgary, 8 Department of Medicine, Cumming School of Medicine, University of Calgary

Background

- Clinical triage tools facilitate pre-hospital recognition of large vessel occlusion (LVO) for endovascular thrombectomy (EVT)
- Tools have variable positive predictive value (PPV), which impacts transport decision-making
- We modelled the effects of the Los Angeles Motor Scale (LAMS) and Ambulance Clinical Triage For Acute Stroke Treatment (ACT-FAST) algorithm, on transport strategies for EVT in Victoria, Australia

Methods

- The PPVs of both screening tools from a prospective validation study, the efficacy decay of alteplase and EVT over time, and treatment and transport times were combined to create a conditional probability model
- Using the model the probability of good outcome (mRS 0 – 1 at 90 days) for both drip-and-ship and mothership transport strategies was predicted
- Colour coded maps were then created depicting the best transport strategy



Time Parameter	Scenario A	Scenario B	Scenario C
Onset to First Medical Contact	30 mins	30 mins	30 mins
Ambulance Response + Scene Time	30 mins	30 mins	30 mins
Door to Needle (thrombolysis centre)	30 mins	60 mins	60 mins
Door In Door Out	50 mins	120 mins	120 mins
Door to Needle (EVT centre)	30 mins	30 mins	60 mins
Door to Groin Puncture	60 mins (mothership) 30 mins (drip and ship)	60 mins (mothership) 30 mins (drip and ship)	90 mins (mothership) 60 mins (drip and ship)

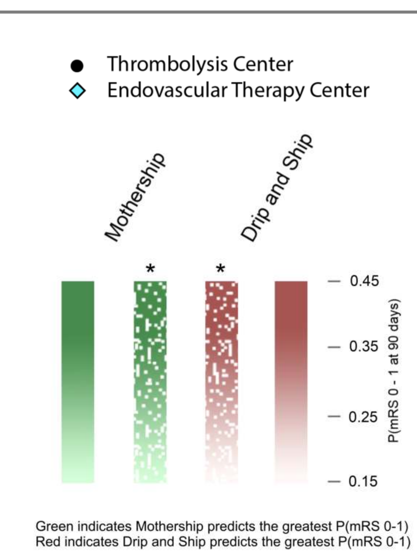


Figure. Maps depicting the best predicted transport strategy for patients with suspected ischemic stroke with large vessel occlusion, defined as Ambulance Clinical Triage For Acute Stroke Treatment (ACT-FAST) positive or Los Angeles Motor Scale (LAMS) Score ≥ 4 in the state of Victoria, Australia. Thrombolysis centres are depicted by black dots and endovascular therapy (EVT) centres are depicted by blue diamonds. Three different treatment efficiency scenarios are shown (Panels A – C). Red indicates areas where drip-and-ship predicts the greatest probability of excellent outcome and green indicates areas where mothership predicts the greatest probability of excellent outcome. White stippling indicates areas where the optimal transport method supersedes the other by 1% or less. The degree of colour saturation reflects the value of the probability of excellent outcome. Grey areas indicate a lack of road infrastructure data thus transport times and therefore optimal transport method could not be determined.

Results

Table 1. Model Components

Model Piece	Components
Probability of Good Outcome	$P_{mRS0\text{-}1 \mid positive\ LVO\ screen} = \alpha\, P_{mRS\ 0\text{-}1 \mid LVO} + \beta\, P_{mRS\ 0\text{-}1 \mid nLVO} + \chi\, P_{mRS\ 0\text{-}1 \mid ICH} + \gamma\, P_{mRS\ 0\text{-}1 \mid SM}$
$P_{mRS\ 0\text{-}1 \mid LVO}$	$P_{mRS\ 0\text{-}1 \mid alteplase} + (1-P_{mRS\ 0\text{-}1 \mid alteplase})*P_{mRS\ 0\text{-}1 \mid EVT}$ $P_{mRS\ 0-1 \mid alteplase} = 0.2359+0.0000002(t_{onset\text{-}to\text{-}needle})^2-0.0004t_{onset\text{-}to\text{-}needle}$ minimum value = 0.1328 $P_{mRS\ 0-1 \mid EVT} = 0.3394+0.00000004(t_{onset\text{-}to\text{-}pucture})^2-0.0002\ t_{onset\text{-}to\text{-}pucture}$ minimum value = 0.129
$P_{mRS\ 0\text{-}1 \mid nLVO}$	$P_{mRS\ 0-1 \mid nLVO} = 0.6343-0.00000005(t_{onset\text{-}to\text{-}needle})^2-0.0005t_{onset\text{-}to\text{-}needle}$ minimum value = 0.4622
$P_{mRS\ 0\text{-}1 \mid ICH}$	0.24, non-time dependent
$P_{mRS\ 0\text{-}1 \mid SM}$	0.90, non-time dependent

α = P(LVO|positive LVO screen); β = P(nLVO| positive LVO screen); χ = P(intracranial hemorrhage| positive LVO screen); γ = P(stroke mimic| positive LVO screen); LVO = large vessel occlusion; nLVO = non-large vessel occlusion; ICH = intracranial hemorrhage; SM = stroke mimic; EVT = endovascular therapy

- Because the PPV of ACT-FAST+ is higher than LAMS ≥4 (56% vs 43%) the areas where mothership predicts the best patient outcome are larger regardless of treatment times at the thrombolysis and EVT centres (Figure)
- This difference is especially pronounced if door to needle times at thrombolysis centres are slow (Figure – Panel B)
- Using ACT-FAST the absolute probability of good outcome decreases as a function of the increased PPV, this is due to more large vessel occlusion strokes (with inherently poorer outcomes than most false positives) being identified

Discussion

- Due to the efficacy of EVT for large vessel occlusion stroke, a triage tool with a high positive predictive value increases the area where a mothership transport strategy predicts the greatest probability of good outcome for patients with suspected large vessel occlusion
- Because screening tool PPV impacts transport decision making, the tool used in each jurisdiction should be taken into consideration when designing EMS coverage areas and transport protocols
- These models represent average patients under average conditions
- In the scenarios where widespread mothership transport is predicted to produce best outcomes, practical considerations such as capacity at the EVT centre, weather, and redundancy in ambulance systems when an ambulance has to travel outside of its jurisdiction are also relevant.

CUMMING SCHOOL OF MEDICINE
Department of Community Health Sciences
Jessalyn K. Holodinsky, MSc
jkholodi@ucalgary.ca