



Assessing Telehealth Accuracy in Prehospital Stroke Assessment and Bypass Triage

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Background:

In Hawaii, approximately 2700 ischemic strokes occur annually. Among these patients, 58% arrive by EMS with 22% receiving thrombolytic therapies. Treatments include mechanical thrombectomy (MT) for large vessel occlusion (LVO) strokes (20%) and tenecteplase (TNK) for non-LVO strokes (80%). EMS utilizes the LAPSS and C-STAT to identify strokes and LVOs, determining whether to bypass to a Comprehensive Stroke Center (CSC). Patients presenting an LVO must be directly transported to a CSC for an immediate MT, while non-LVO patients should be transported to the nearest hospital for TNK.

Telemedicine (Pulsara) has been implemented to assist EMS with determining C-STAT status for bypass to the CSC and decreasing treatment times. Smaller onset-to-treatment windows have previously been associated with improved functional outcomes. Thus, this research will evaluate how prehospital telemedicine affects patient outcomes and efficacy of bypass triage.

Methods:

This study analyzed a prospectively collected database of 1409 consecutive patients evaluated by prehospital telemedicine for suspected stroke. EMS was trained to activate telemedicine based on a positive LAPSS score or a high clinical suspicion of stroke. A virtual neurologist sequentially triaged the patient with a brief (~3 minute) video evaluation to determine the C-STAT status. The study interval stretched from August 2022 to June 2026.

A retrospective review was conducted to assess the accuracy of video evaluation for identifying patients with an LVO and those treated with an MT. The analysis focused on descriptive statistics to investigate the prehospital C-STAT accuracy and bypass triage patterns. Pearson's Chi-squared test was used to assess whether there was an association between TNK and MT rates between PB and non-PB hospitals. The Kruskal-Wallis rank sum test determined if there were any significant differences between the ED door and 911 call-to-treatment times between PB and non-PB hospitals.

Characteristic	Overall N = 1,038 ¹	Bypass Averted N = 560 ¹	Bypassed Direct to PB N = 478 ¹
C-STAT Positive	408 (39%)	27 (4.8%)	381 (80%)
LVO Present	210 (20%)	33 (5.9%)	177 (37%)
Mechanical Thrombectomy	133 (13%)	17 (3.0%)	116 (24%)

Figure 1: Bypass Triage to the CSC and Corresponding Clinical Data on Oahu

Characteristic	Overall N = 1,409 ¹	PB N = 478 ¹	Non-PB Hospitals N = 560 ¹	Big Island N = 371 ¹
Video Call Status				
Failed	137 (9.7%)	39 (8.2%)	39 (7.0%)	59 (16%)
Successful	1,272 (90%)	439 (92%)	521 (93%)	312 (84%)

Figure 2: Video Call Success Rates by Hospital Destination

Characteristic	Overall N = 1,409 ¹	PB N = 478 ¹	Non-PB Hospitals N = 560 ¹	Big Island N = 371 ¹
Age Group				
18–44 (young adult)	98 (7.0%)	29 (6.1%)	51 (9.1%)	18 (4.9%)
45–64 (middle age)	383 (27%)	121 (25%)	166 (30%)	96 (26%)
65–84 (older adult)	707 (50%)	240 (50%)	268 (48%)	199 (54%)
≥ 85 (very old)	219 (16%)	88 (18%)	73 (13%)	58 (16%)
Gender				
F	662 (47%)	227 (47%)	272 (49%)	163 (44%)
M	747 (53%)	251 (53%)	288 (51%)	208 (56%)
Initial NIHSS (In-Hospital)	6 (2, 15)	16 (8, 22)	3 (1, 6)	5 (2, 11)
Any Thrombolytic Administered	297 (21%)	157 (33%)	62 (11%)	78 (21%)

Figure 3: Demographics Including Initial NIHSS Score and Treatment Rates

Characteristic	Overall N = 1,409 ¹	PB N = 478 ¹	Non-PB Hospitals N = 560 ¹	Big Island N = 371 ¹
Final Diagnosis				
Intracerebral Hemorrhage	186 (13%)	100 (21%)	37 (6.6%)	49 (13%)
Ischemic Stroke	660 (47%)	258 (54%)	226 (40%)	176 (47%)
Stroke Mimic	446 (32%)	104 (22%)	234 (42%)	108 (29%)
TIA	116 (8.2%)	16 (3.3%)	63 (11%)	37 (10.0%)
Unknown	1 (<0.1%)	0 (0%)	0 (0%)	1 (0.3%)
Most Common Stroke Mimics				
Metabolic Encephalopathy	162 (37%)	44 (43%)	79 (34%)	39 (37%)
Seizure	86 (20%)	26 (25%)	39 (17%)	21 (20%)
Other	51 (12%)	9 (8.7%)	27 (12%)	15 (14%)
Migraine	40 (9.1%)	5 (4.9%)	25 (11%)	10 (9.5%)

Figure 4: Final Diagnosis and Stroke Mimics

Characteristic	Overall N = 297 ¹	PB N = 157 ¹	Non-PB Hospitals N = 62 ¹	Big Island N = 78 ¹
NIHSS Reduction	8 (3, 13)	11 (6, 16)	4 (2, 7)	6 (3, 11)
Discharge mRS Score	3.00 (1.00, 4.00)	3.00 (2.00, 4.00)	2.00 (1.00, 3.00)	2.00 (2.00, 3.00)
In-Hospital Mortality				
Deceased	31 (11%)	19 (12%)	6 (9.7%)	6 (7.8%)
Survived	263 (89%)	136 (88%)	56 (90%)	71 (92%)

Figure 5: Clinical Outcomes for Patients who Received Any Thrombolytic Treatments

Treatment and Telemedicine

Of the 1409 patients in this study population, 297 individuals received thrombolytic treatments.

- A significant association was found between the 3 hospital groups and TNK/MT rates, as well as the time frames from the ED door/911 call-to-treatment (p-values < 0.001)
- Video calls received a 90% overall success rate categorized by whether sufficient virtual communication was established between EMS and the neurologist
- Telemedicine utilization increased with each year starting in 2022 to the projected number in 2026
- Metabolic Encephalopathy was the most frequently observed stroke mimic

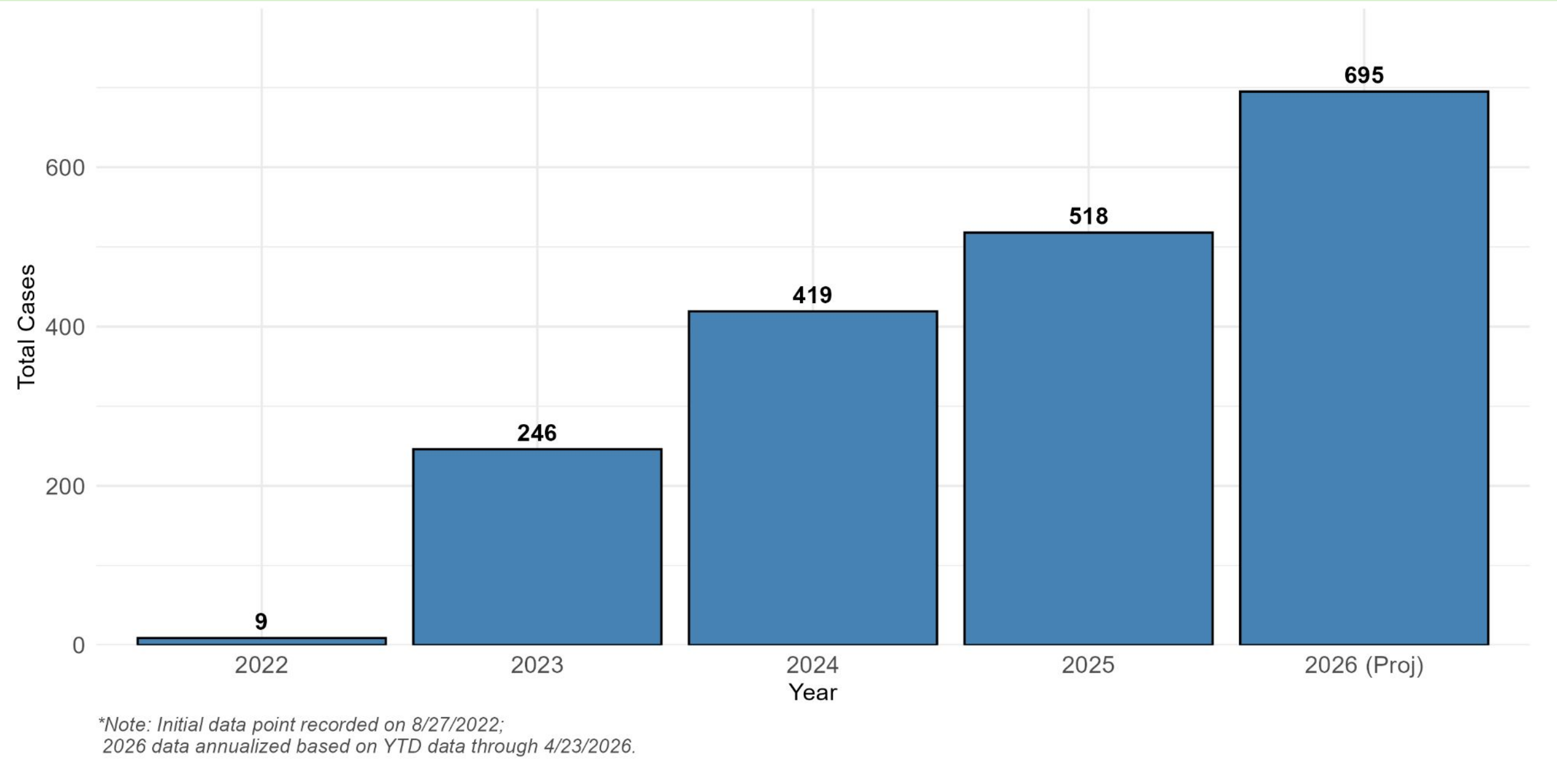


Figure 6: Total Number of Pulsara Activations in Each Year from 2022-2026

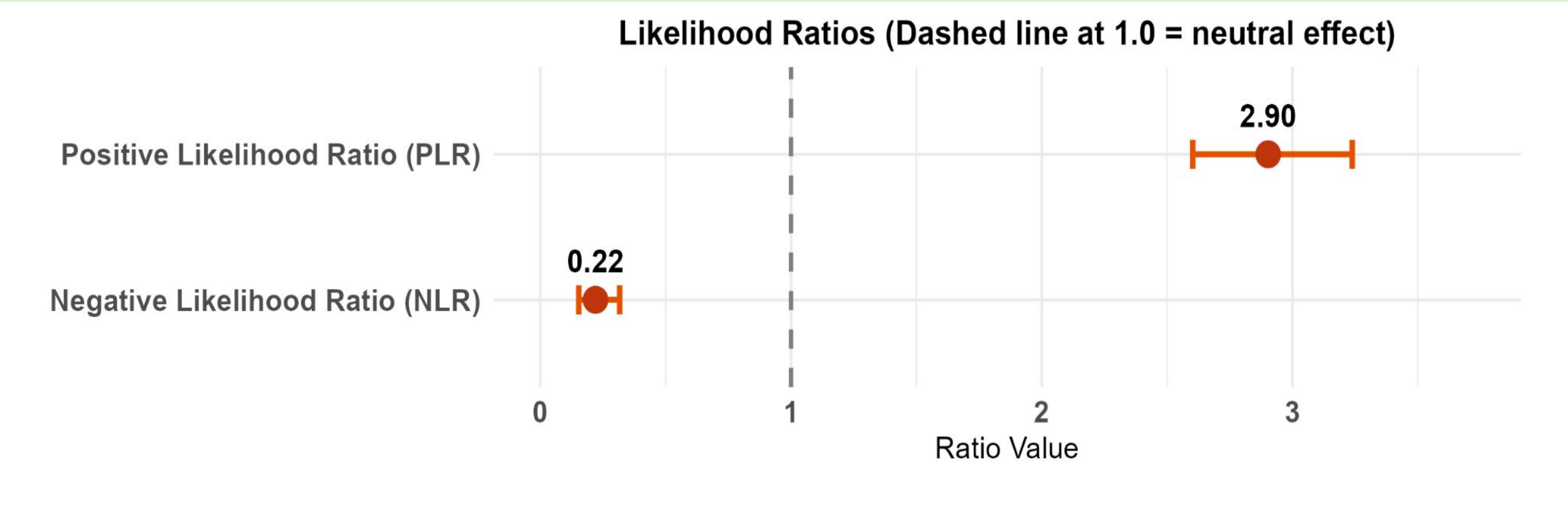


Figure 7: C-STAT Likelihood Ratios for MT

Characteristic	N	Overall N = 1,409 ¹	PB N = 478 ¹	Non-PB Hospitals N = 560 ¹	Big Island N = 371 ¹	p-value ²
TNK Administered (Rate)	1,409	205 (15%)	89 (19%)	51 (9.1%)	65 (18%)	<0.001
ED Door to TNK Time (mins)	204	28 (19, 45)	20 (14, 28)	31 (21, 49)	40 (28, 59)	<0.001
911 Call to TNK Time (mins)	195	79 (65, 98)	74 (63, 88)	74 (63, 106)	94 (75, 110)	<0.001
Thrombectomy Performed (Rate)	1,409	160 (11%)	116 (24%)	17 (3.0%)	27 (7.3%)	<0.001
ED Door to Puncture Time (mins)	159	98 (73, 158)	81 (67, 103)	170 (149, 197)	376 (287, 465)	<0.001
911 Call to Puncture Time (mins)	155	151 (127, 199)	140 (122, 158)	230 (192, 258)	417 (332, 511)	<0.001

Figure 8: Comparison of TNK and MT Treatment Rates and Times between Hospital Groups

Patient Treatment Clinical Outcomes

- PB showed the largest reduction in NIHSS scores
 - The median mRS scores ranged between 2 and 3 across all three hospitals
 - Among 297 patients treated with TNK and/or MT, the hospital-overall survival rates were 90%
- ### Oahu Bypass Triage
- Number of patients on Oahu who bypassed to the CSC (PB) was 478, and 381 individuals were C-STAT positive, 177 presented an LVO, and 116 underwent an MT
 - 8,652 miles were saved from averting bypass with a median of 17 miles
 - The number needed to bypass to achieve one MT was 3.4
 - Avert bypass rate was 54% (n = 560), while 97 patients required subsequent transfer to the CSC with 17 individuals receiving an MT (false negative rate = 3%) and 33 presenting an LVO
 - On Oahu, 338 patients had a final diagnosis of stroke mimic, and 234 of them averted bypass (69%)

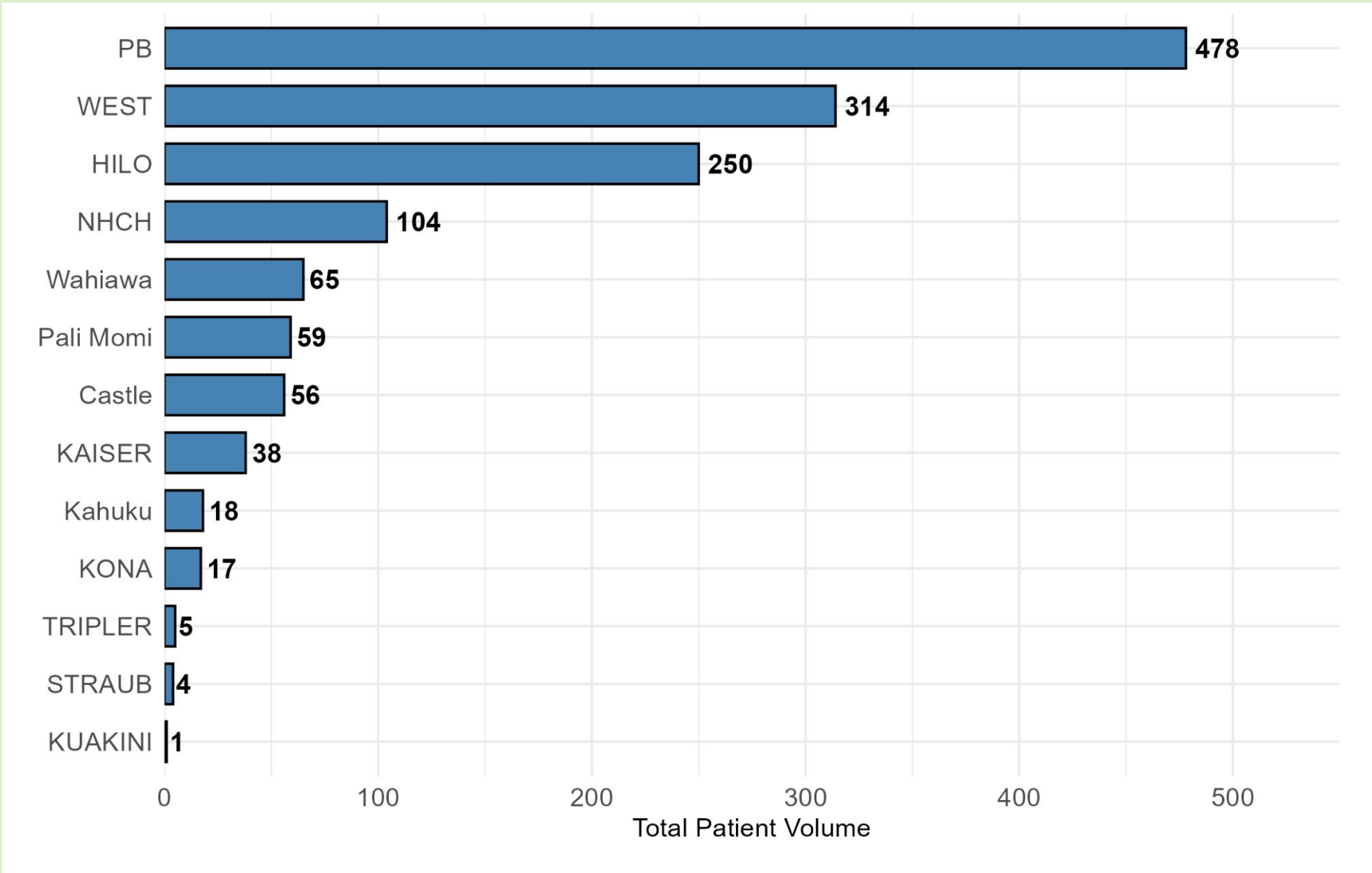
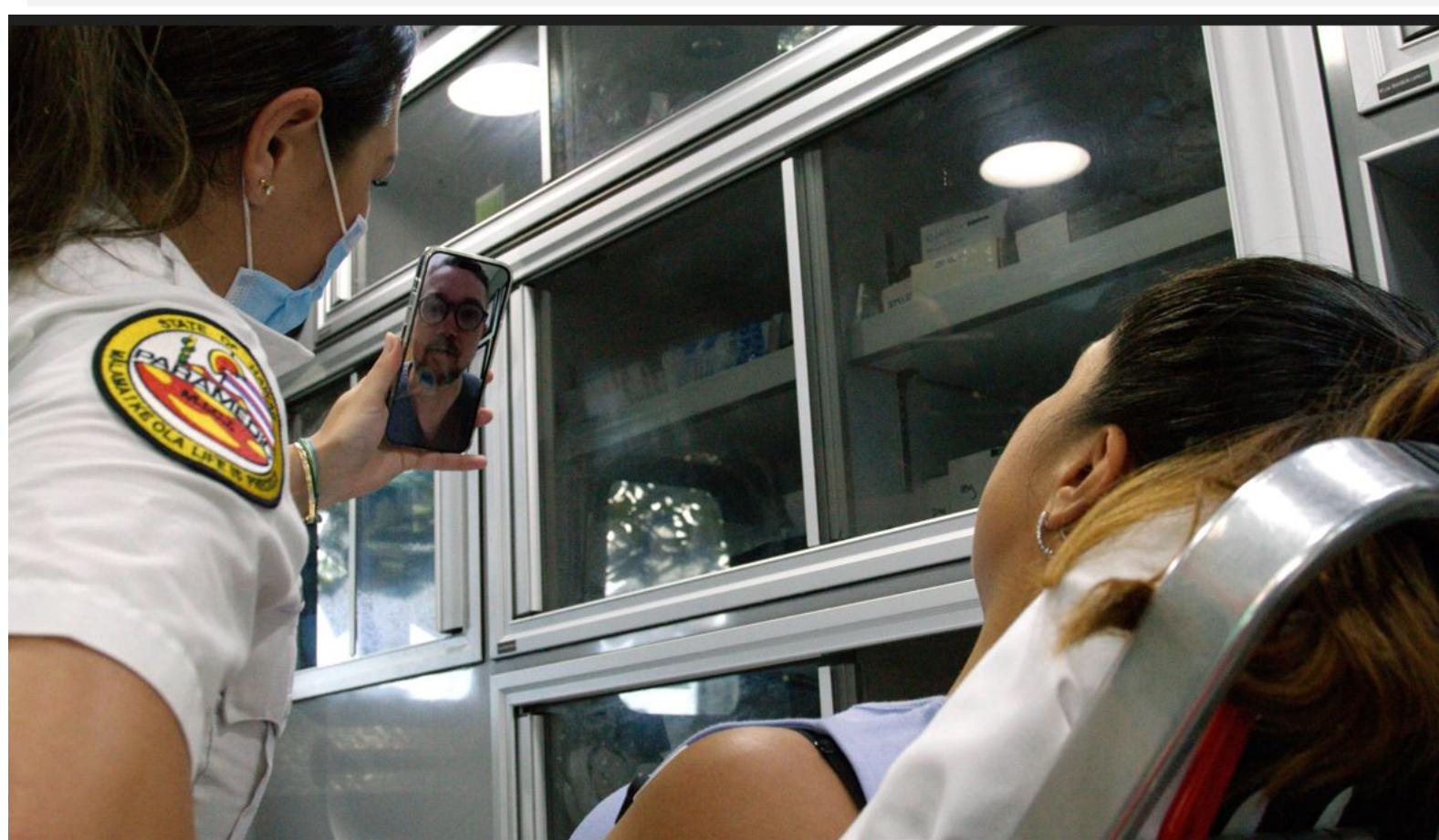


Figure 9: Hospital Destinations for EMS Pulsara Activation

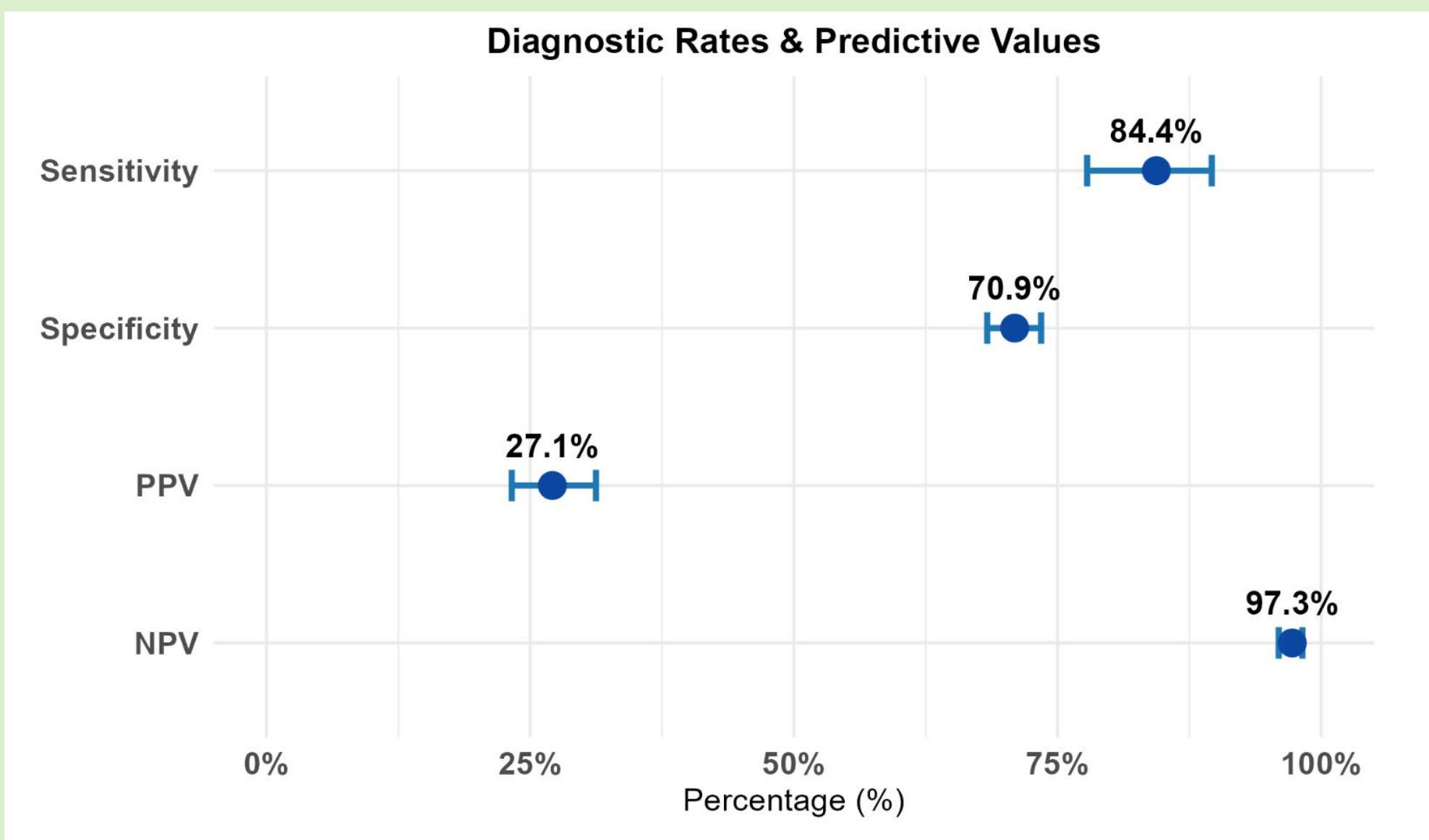


Figure 10: C-STAT Accuracy Parameters for MT

Prehospital Stroke Assessment Tool (C-STAT)

- C-STAT demonstrated a sensitivity of 84.4% (95% CI: 77.8% - 89.6%), specificity of 70.9% (95% CI: 68.3% - 73.4%), PPV of 27.1% (95% CI: 23.2% - 31.2%), and a NPV of 97.3% (95% CI: 96.0% - 98.2%)
- C-STAT also showed a PLR for MT of 2.90 (95% CI: 2.60 - 3.24) and a NLR of 0.22 (95% CI: 0.15 - 0.32)

Discussion/Conclusion:

Study results suggest that a brief video consultation complemented with C-STAT screening led to an earlier recognition of LVO strokes and direct transportation to the CSC for evaluation for MT.

- C-STAT's high sensitivity and NPV ensured that patients presenting LVO needing an MT were consistently identified
- Positive C-STAT screening increased the likelihood of receiving a MT by almost three-fold, while a negative C-STAT reduced this likelihood by nearly five times
- The very low false negative rate minimized unnecessary interhospital transfers for missed LVOs
- Almost 70% of patients on Oahu presenting a stroke mimic averted bypass, likely allowing them to reach necessary treatments more rapidly
- The number needed to bypass was relatively strong, showing that for every 3.4 patients bypassed to PB, one of them ended up receiving an MT

Similar 911 call-to-treatment times between PB and non-PB hospitals suggests that bypass triage protocols effectively expedite the workflow between EMS and receiving hospitals

The impact of prehospital telemedicine on improving thrombolytic treatment rates requires further investigation.

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