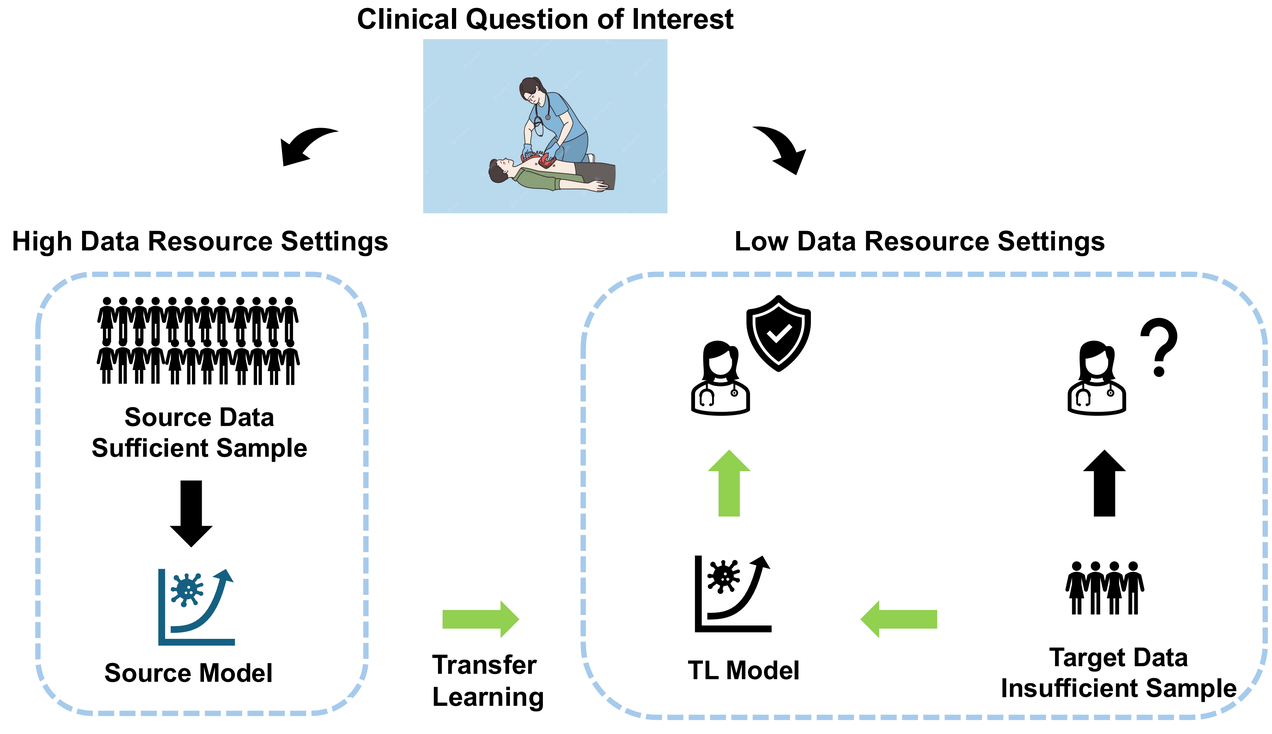
Transfer Learning Enhances Neurological Outcome Prediction for Out-of-Hospital Cardiac Arrest: Validation Across Diverse Geographic Contexts

Siqi LI, PhD[1], Yohei OKADA, PhD[1], Wenjun GU, MSc[1], Michael Hao CHEN, BSc[1], Marcus Eng Hock ONG, MPH[1], Nan LIU, PhD[1]
[1]Duke-NUS Medical School, Singapore, Singapore
Contact: siqili@u.duke.nus.edu

nliulab/
Clinical-Transfer-Learning

Background

Developing accurate risk stratification models for out-of-hospital cardiac arrest (OHCA) in low-resource settings is challenging due to small sample sizes and poor data quality. The Pan-Asian Resuscitation Outcomes Study (PAROS) network[1], established in 2009, offers a multicentre OHCA registry across Asia-Pacific. However, data limitations in countries like Vietnam hinder model development, and directly applying models from high-resource settings often leads to poor performance. To address this, we applied transfer learning (TL)[2], a machine learning technique that adapts existing OHCA models to new datasets.



Method

The Trans-Lasso[3] algorithm was used to adapt the source model by Nishioka et al.[4] to Singapore and Vietnam cohorts from the PAROS registry. While our analysis retained the same predictors as the original model, our outcome of interest was good neurological outcomes, unlike the original study. TL models were initialized with coefficients from the source study and refined using Vietnam and Singapore data as target datasets. For comparison, the original source model's performance was directly evaluated on both target datasets.

Results

The original source model performed poorly on the Vietnam cohort, with an Area Under the Receiver Operating Characteristic curve (AUROC) of 0.467 (95% CI: 0.141-0.785). In contrast, the TL model significantly improved performance (AUROC = 0.807, 95% CI: 0.626-0.948) and also enhanced the Area Under the Precision-Recall Curve (AUPRC), as shown in Table 1. For the Singapore cohort, the TL model showed modest improvements in both AUROC and AUPRC, demonstrating its potential to boost predictive performance, especially in data-limited, low-resource settings.

Cohort	Model Type	AUROC (95% CI)	AUPRC	Specificity at Sensitivity = 0.55	Specificity at Sensitivity = 0.85
Vietnam (n=243)	Source	0.467 (0.141-0.785)	0.428	0.707	0.000
	TL	0.807 (0.626-0.959)	0.889	0.902	0.511
Singapore (n=15,916)	Source	0.945 (0.929-0.958)	0.527	0.986	0.908
	TL	0.955 (0.940-0.967)	0.885	0.990	0.920

Conclusion

This study[5] highlights TL's potential to address regional resource disparities in healthcare. Although applied to OHCA here, TL could be extended to other low-outcome conditions like trauma, sepsis, heart failure, and stroke. Its adaptability also opens doors for broader clinical applications beyond emergency medicine. By reducing reliance on extensive data collection and collaboration, TL offers a scalable, efficient strategy to enhance clinical decision-making, reduce healthcare inequities, and optimize outcomes in diverse, data-constrained settings.

References

1. Ong, Marcus Eng Hock, et al. "Pan-Asian resuscitation outcomes study (PAROS): rationale, methodology, and implementation." Academic Emergency Medicine 18.8 (2011): 890-897.
2. Li, Siqi, et al. "Bridging Data Gaps in Healthcare: A Scoping Review of Transfer Learning in Structured Data Analysis." Health Data Science 5 (2025): 0321.
3. Li, Sai, T. Tony Cai, and Hongzhe Li. "Transfer learning for high-dimensional linear regression: Prediction, estimation and minimax optimality." Journal of the Royal Statistical Society Series B: Statistical Methodology 84.1 (2022): 149-173.
4. Nishioka, Norihiro, et al. "External Validation of Updated Prediction Models for Neurological Outcomes at 90 Days in Patients With Out-of-Hospital Cardiac Arrest." Journal of the American Heart Association 13.9 (2024): e033824.
5. Li, Siqi, et al. "Leveraging AI and Transfer Learning to Enhance Outcome Prediction for Out-of-Hospital Cardiac Arrest in Diverse Settings: Insights from the Pan-Asian Resuscitation Outcomes Study." npj Digital Medicine, in press, 2025. Preprint, bioRxiv, https://doi.org/10.1101/2025.05.11.25327388.