# Predicting Risk of Neurologic Patient Readmission

## Validating and Improving the Neuro $R^2$ Score

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## Introduction

- Approximately two million hospital readmissions occur annually and cost Medicare nearly $26 billion dollars[1].
- The Neuro $R^2$ score was designed by the Mayo Clinic to predict the risk of readmission within 30 days of recent hospitalization in patients with neurological disorders and based on common clinical characteristics[2][3].
- It remains unknown whether the prediction model is broadly applicable, particularly when incorporating patient characteristics strongly associated with healthcare disparities[1].

## Objective

To test the performance by external validation of the Neuro $R^2$ score and develop an independent machine learning model that accounts for readmission disparities.

## Design/Methods

- Retrospective analysis of 4,117 admitted patients with neurological disease at the University of California Davis Medical Center between June 2016 to March 2020.
- This study compares three different machine learning models:

| | Model Creator | Data Used for Training |
|---|---|---|
| Neuro $R^2$ Score | Mayo Clinic | Mayo Clinic Patients |
| Refitted Neuro $R^2$ Model | Mayo Clinic | UC Davis Patients |
| UC Davis Model | UC Davis | UC Davis Patients |

## Results

- 310 of 4,117 patients (7.5%) were readmitted within 30 days of a prior neurologic admission
- The UC Davis Model outperformed both the Neuro $R^2$ Score and Refitted Neuro $R^2$ Model

| | Average Precision | C statistic |
|---|---|---|
| Neuro $R^2$ Score | 0.11 | 0.56 |
| Refitted Neuro $R^2$ Model | 0.17 | 0.67 |
| UC Davis Model | 0.20 | 0.70 |

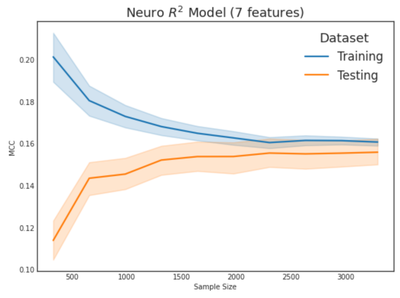
## Neuro $R^2$ Model Trained with Mayo vs UC Davis Patient Data

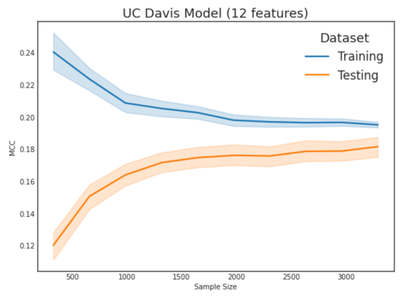
- UC Davis patients with cerebrovascular disease or discharged to rehab were *less likely* to be readmitted
- Most Mayo features were statistically insignificant at UC Davis

| Effect | Odds Ratio | | $\Pr < \chi^2$ | |
|---|---|---|---|---|
| | Mayo | Davis | Mayo | Davis |
| Charlson disease count | 1.20 | 1.21 | 0.005 | <0.001 |
| Urgent/emergent admission | 1.50 | 1.07 | 0.03 | 0.058 |
| Discharge to rehabilitation | 1.66 | 0.90 | 0.005 | 0.002 |
| Charlson-cancer (not metastatic) | 1.70 | 1.02 | 0.007 | 0.625 |
| Brain tumor | 1.82 | 1.03 | 0.03 | 0.379 |
| Charlson-cerebrovascular disease | 2.18 | 0.379 | <0.001 | 0.008 |
| Discharge to SNF | 2.43 | 1.04 | <0.001 | 0.242 |

## Neuro $R^2$ Model Bias

- The Neuro $R^2$ training and test performance overlap at 1,700 samples showing it to have a high bias
- Biased models can be improved by adding features, in this case patient characteristics



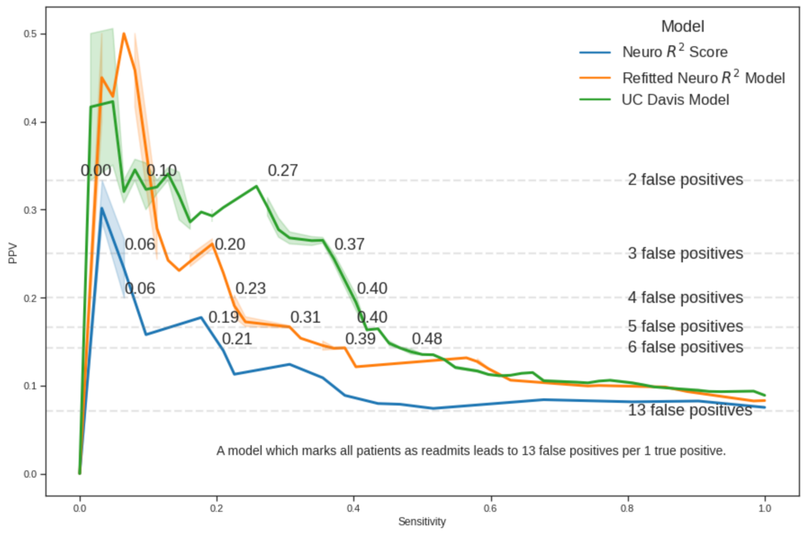




## Selecting Patient Features for the UC Davis Model

Relief-based feature selection organizes patients into "neighborhoods" based on similar characteristics and then finds differences which are most associated with readmission[4]

| **Increased** Readmission Risk | **Decreased** Readmission Risk |
|---|---|
| Charlson disease count | Commercial PPO coverage |
| Primary Dx of trauma or MSK | Medicare Managed Care coverage |
| Malignant neoplasm of the brain | Discharge to Rehabilitation |
| Admitted through ER | |
| Discharged to SNF or Home Health | |
| Medicaid Managed Care coverage | |
| African American Race | |

## Sensitivity and Positive Predictive Value of Models




## Conclusion

- The Neuro $R^2$ score poorly predicted the risk of readmission in our sample population at an urban academic tertiary referral center
- Adding race, insurance status, and recovery intervention features to our machine learning model enabled it to outperform the Neuro $R^2$ score.

## Further Reading

To learn more, visit https://bit.ly/39NjFwY.

## References

[1] Centers for Medicare and Medicaid Services . Guide to Reducing Disparities in Readmissions 2018.
[Online; accessed 11-Feb-2021].

[2] Peacock Sarah H., Grek Ami A., Rogers Emily R., et al. Neuro R2 score *Neurology.* 2020;94:e1614–e1621.

[3] Charlson M. E., Pompei P., Ales K. L., MacKenzie C. R.. A new method of classifying prognostic comorbidity in longitudinal studies: development and validation *J Chronic Dis.* 1987;40:373–383.

[4] Urbanowicz Ryan J., Olson Randal S., Schmitt Peter, Meeker Melissa, Moore Jason H.. Benchmarking Relief-Based Feature Selection Methods for Bioinformatics Data Mining 2018.