Relapse of Myocardial Infarction

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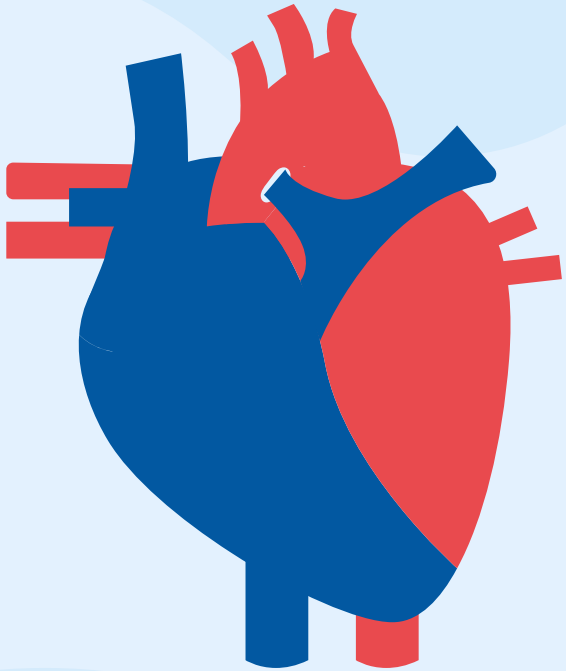
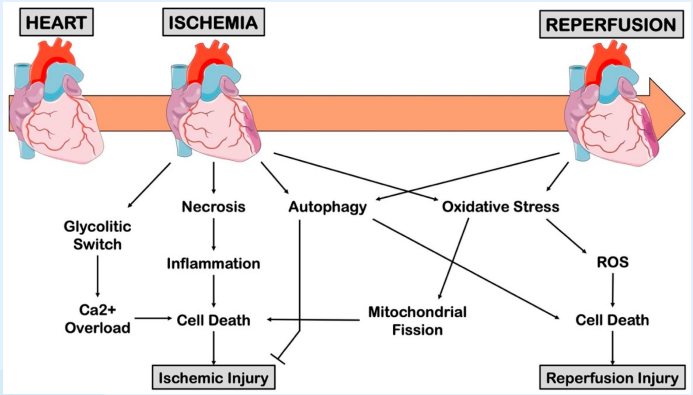
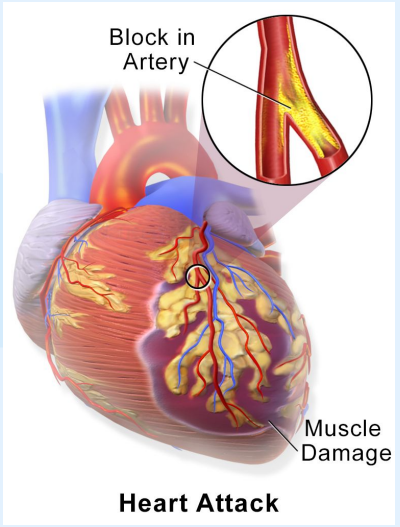


What is MI?

Heart muscle cannot get oxygen anymore and **fails to pump blood** to rest of body





Recurrent MI

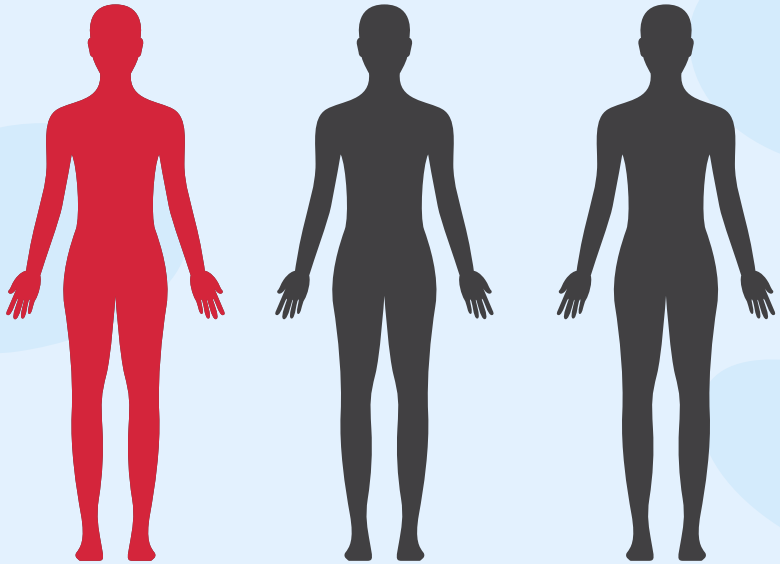
800,000

Heart attacks in the US every year

25%

of these MI are recurrent

The Issue



1 in 3 patients die within a year after a recurrent MI

“Characterizing the predictors of recurrent AMI [acute MI] can improve survival rates of patients”

https://heart.bmj.com/content/107/4/313

Research Question

Which **covariates** are correlated with a **relapse of MI** at various time points in a patient's trajectory?

Project Timeline

01

Data Cleaning

Missing data & Imputation

02

Covariate Analysis

Forward/ Backward Selection & Lasso Regression

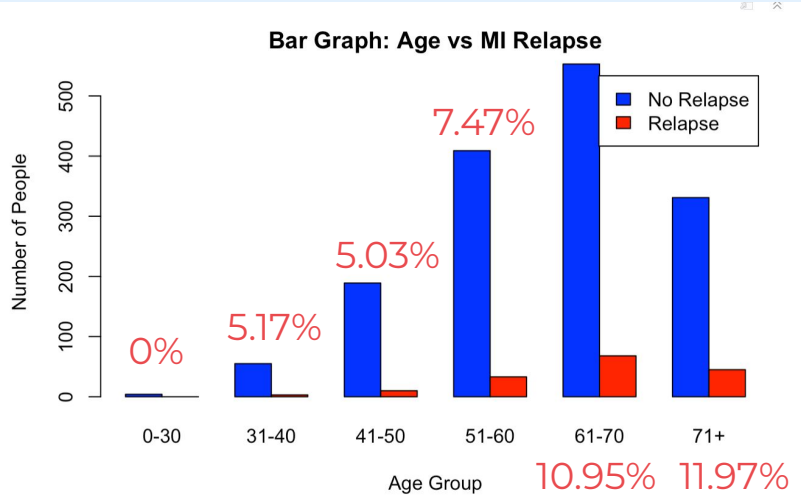
03

Validation

Calibration & Discrimination

What does the data look like?

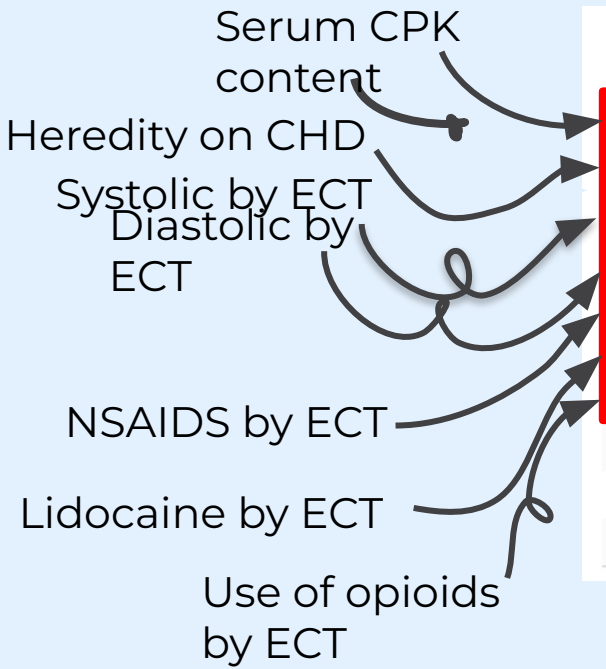
- Collected in the Krasnoyarsk Interdistrict Clinical Hospital in 1992-1995
- 1700 patients
- 111 input features and 12 complications
- 7.6% missing data
- Roughly 90% of patients did not have relapse of MI



Percentages in red show relapse rate in that age group

Missing Data

- Originally wanted to remove variables with missing data > 25%
- Looked into what the variables actually meant
- ECT Subset



variable <chr>	n_miss <int>	pct_miss <dbl>
KFK_BLOOD	1696	99.76470588
IBS_NASL	1628	95.76470588
S_AD_KBRIG	1076	63.29411765
D_AD_KBRIG	1076	63.29411765
NOT_NA_KB	686	40.35294118
LID_KB	677	39.82352941
NA_KB	657	38.64705882
GIPER_NA	375	22.05882353
NA_BLOOD	375	22.05882353
K_BLOOD	371	21.82352941

Missing Rows ECT

632 Overlapping

Opioids, NSAID, Lidocaine

1076 Overlapping

Systolic, Diastolic BP

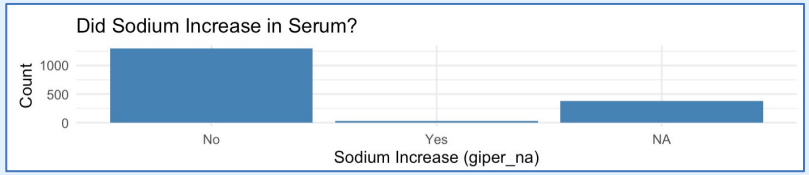
1161 Overlapping

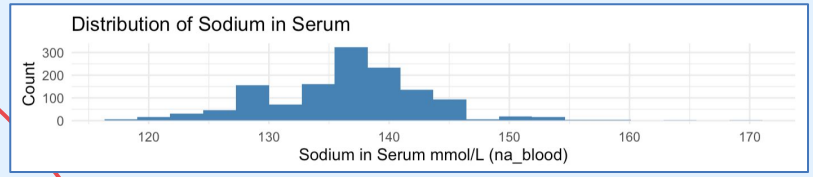
Imputing the Data

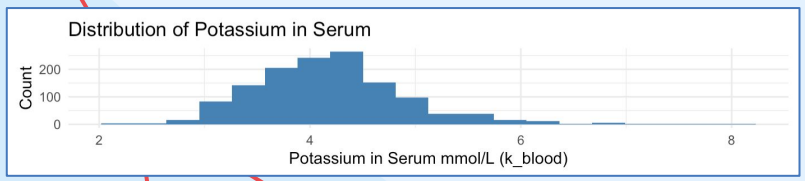
- **0 patients** with complete data
- Used **mice** package in R to impute data
- Predictive mean matching

Data Distribution

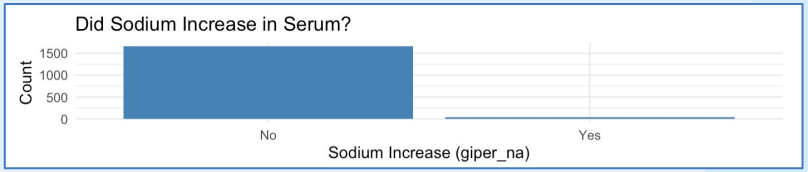
Before Imputation

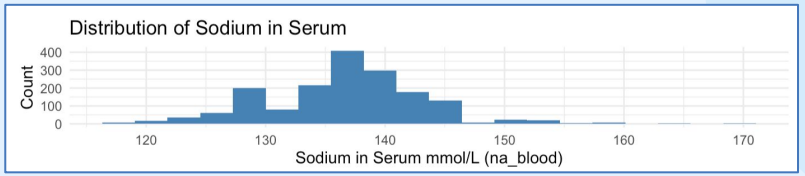


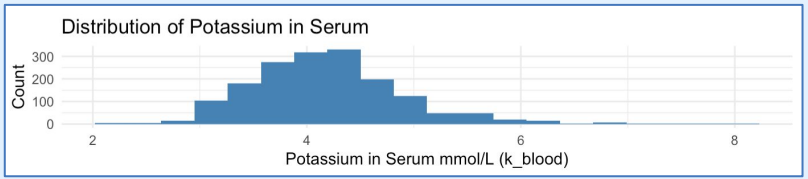




After Imputation







Data Distribution

Before Imputation

Did Sodium Increase?

Yes	No	NA
76.17%	1.64%	22.06%

Ratio of Yes:No is 97.89% to 2.11%

After Imputation

Did Sodium Increase?

Yes	No	NA
97.65%	2.35%	0%

Data Distribution

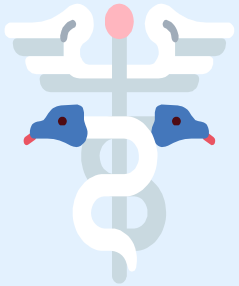
Sodium in Serum Measures	Before Imputation Freq.	After Imputation Freq.
(110,115]	0.000	0.000
(115,120]	0.014	0.012
(120,125]	0.036	0.035
(125,130]	0.144	0.143
(130,135]	0.175	0.175
(135,140]	0.422	0.416
(140,145]	0.127	0.130
(145,150]	0.063	0.070
(150,155]	0.013	0.013
(155,160]	0.006	0.006

Data Distribution

Potassium in Serum Measures	Before Imputation Freq.	After Imputation Freq.
(2,3.17]	0.057	0.054
(3.17,4.33]	0.578	0.585
(4.33,5.5]	0.318	0.315
(5.5,6.67]	0.038	0.037
(6.67,7.83]	0.008	0.009
(7.83,9]	0.002	0.001

Splitting the Data

- Split into different time points
- Subsets
  - Admission (General) → 96 covariates
    - Anamnesis → 29 covariates
    - Hospital Admission → 40 covariates
  - Stay (General) → 9 covariates
  - ICU → 29 covariates
  - ECT → 5 covariates, 539 patients



Multicollinearity

Subset	Variable Removed
Admission (General)	ECG rhythm at time of admission (sinus)
Stay (General)	None
Anamnesis	Symptomatic hypertension
Hospital Admission	ECG rhythm at time of admission (sinus)
ICU	None
ECT	None

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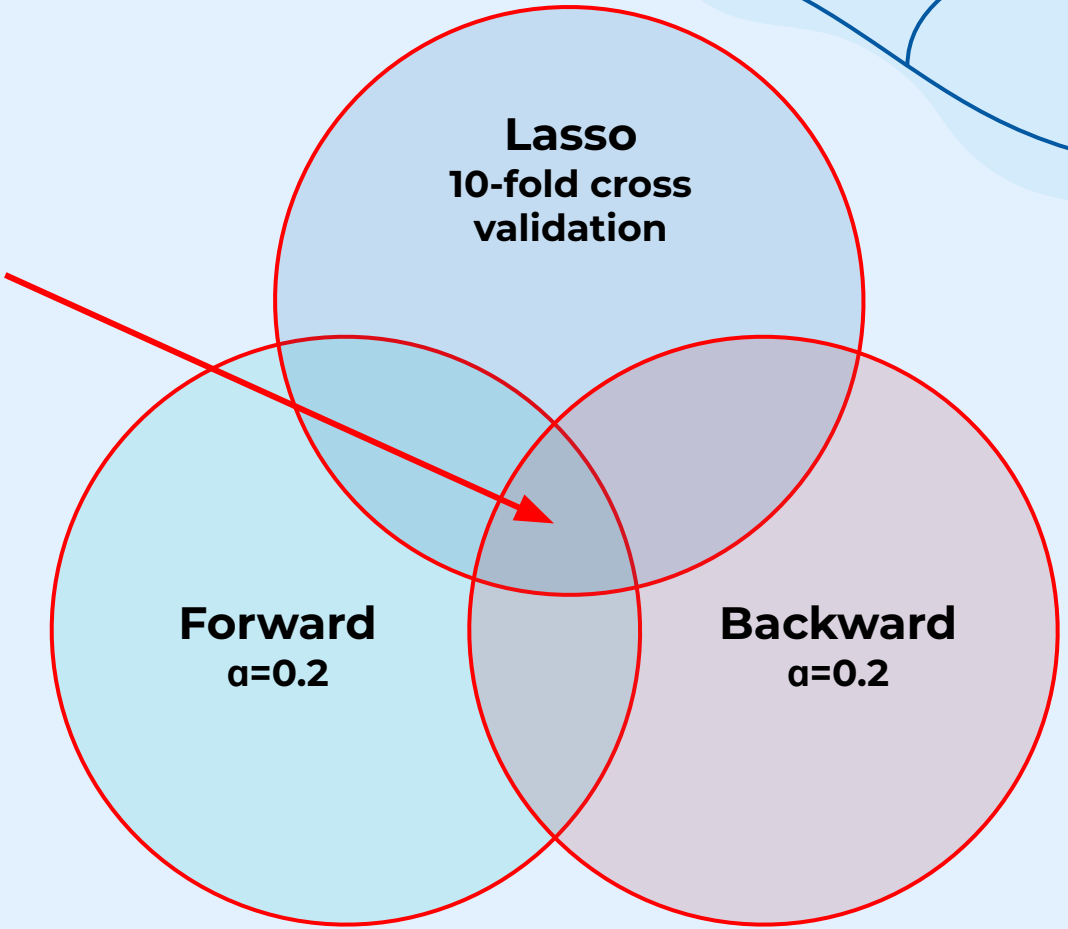
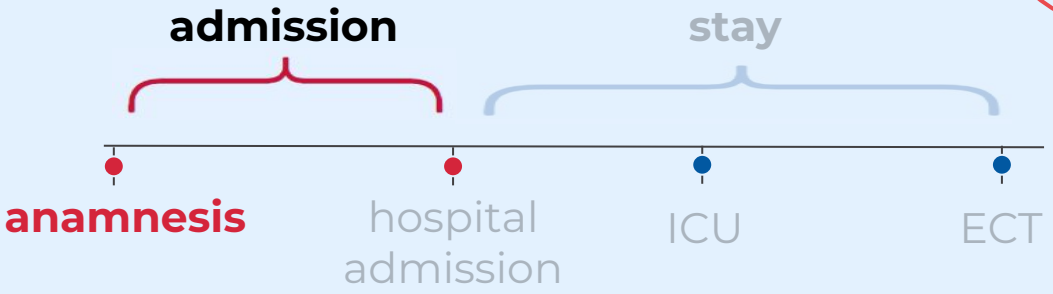
Model Selection





Anamnesis Covariates

Positive Association

- Age
- Exertional angina pectoris
- 1st-degree AV block
- Obstructive chronic bronchitis
- Paroxysms of afib

Negative Association

- Chronic bronchitis
- Observing of arrhythmia

Anamnesis

	Estimate	Pr(>|z|)
(Intercept)	-4.025	0.000
STENOK_AN	0.162	0.000
AGE	0.020	0.014
zab_leg_01	-0.931	0.047
zab_leg_02	0.557	0.033
nr_03	0.820	0.064
nr_11	-0.966	0.189

Hospital Admission Covariates

Positive Association

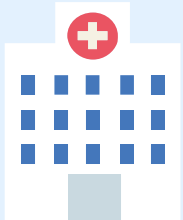
- White blood cell count
- Tachycardia

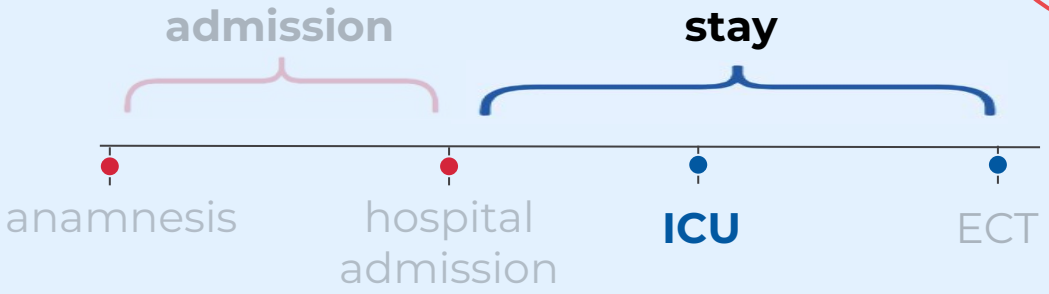
Negative Association

- Time elapsed from beginning of CHD attack to hospital
- Premature ventricular contractions on ECG
- Frequent premature ventricular contractions on ECG

Hospital Admission

	Estimate	Pr(>|z|)
(Intercept)	-2.629	0.000
L_BLOOD	0.056	0.013
TIME_B_S	-0.041	0.172
ritm_ecg_p_07	0.396	0.032
n_r_ecg_p_03	-0.439	0.123
n_r_ecg_p_04	-0.470	0.323





ICU Covariates

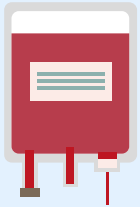
Positive Association

- Use of anticoagulants
- Use of opioid drugs (1st & 2nd day)
- Relapse of pain (3rd day)
- Paroxysms of ventricular tachycardia at the time of admission

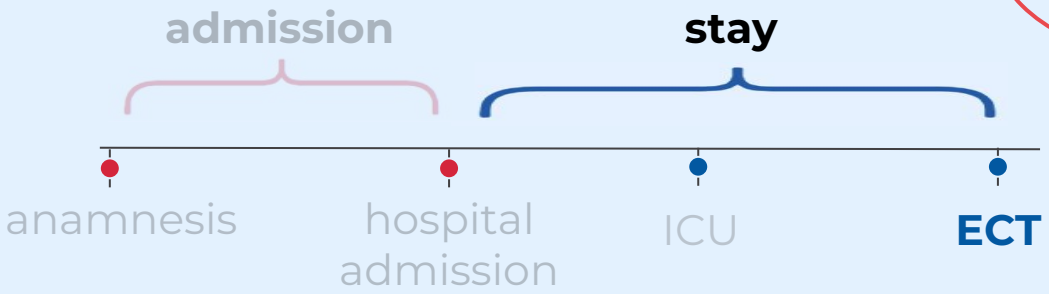
Negative Association

- Diastolic BP
- Presence of inferior MI
- Use of Trental
- Use of calcium channel blockers

ICU



	Estimate	Pr(>|z|)
(Intercept)	-2.297	0.000
D_AD_ORIT	-0.003	0.508
inf_im	-0.132	0.045
GEPAR_S_n	0.477	0.023
R_AB_3_n	0.934	0.000
GT_POST	1.898	0.012
NA_R_2_n	0.380	0.042
TRENT_S_n	-0.416	0.079
ANT_CA_S_n	-0.271	0.130
NA_R_1_n	0.186	0.067



ECT Covariates

Positive Association

- Diastolic BP
- Use of NSAIDs

Negative Association

- None

ECT

	Estimate	Pr(>|z|)
(Intercept)	-4.083	0.000
D_AD_KBRIG	0.013	0.167
NOT_NA_KB	0.683	0.165

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Final Model – Admission (1)

1. Presence of lateral MI
2. Use of calcium channel blockers in ICU
3. Paroxysms of AFIB in anamnesis
4. Increase of sodium in serum
5. White blood cell count
6. Exertional angina pectoris in the anamnesis
7. 1st-degree AV block at time of admission
8. Paroxysms of ventricular tachycardia at time of admission
9. Cardiogenic shock at time of admission to ICU
10. Ventricular fibrillation at time of admission to ICU
11. Chronic bronchitis in anamnesis

Final Model – Admission (2)

12 Diabetes mellitus in anamnesis

13 Use of liquid nitrates in the ICU

14 Use of heparin in ICU

15 Coronary heart disease in recent weeks

16 Use of trental in ICU

17 Incomplete RBBB at the time of admission to hospital

18 Age

19 First degree AV block in anamnesis

20 Persistent form of AFIB at the time of admission to hospital,

21 Complete RBBB in anamnesis,

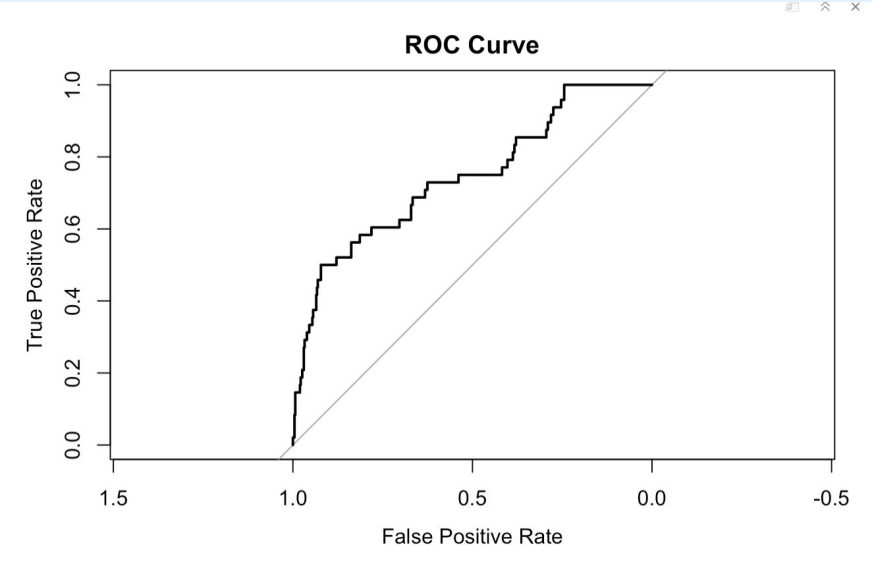
22 ECG rhythm at the time of admission to hospital – AFIB

Final Model – Admission

Logistic Regression

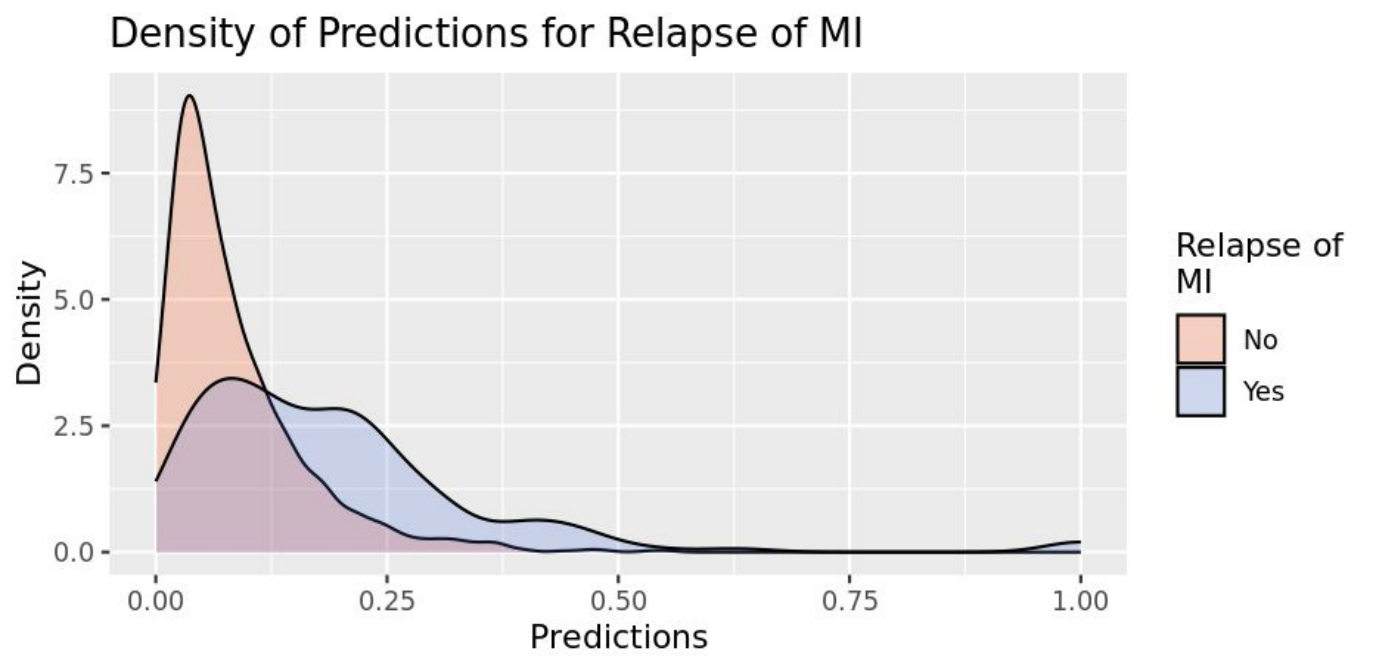
	Estimate	Pr(>|z|)
(Intercept)	-5.806	0.000
lat_im	0.144	0.121
ANT_CA_S_n	-0.344	0.059
nr_03	0.891	0.060
GIPER_NA	0.766	0.113
L_BLOOD	0.071	0.003
STENOK_AN	0.166	0.000
n_p_ecg_p_03	-1.762	0.091
n_r_ecg_p_09	2.438	0.098
K_SH_POST	-29.529	0.974
zab_leg_01	-1.071	0.041
FIB_G_POST	1.346	0.067
endocr_01	0.354	0.114
NITR_S	0.360	0.139
GEPAR_S_n	0.436	0.044
IBS_POST	0.265	0.043
TRENT_S_n	-0.410	0.095
n_p_ecg_p_11	1.329	0.005
AGE	0.029	0.001
np_01	21.731	0.996
n_r_ecg_p_06	-28.850	0.977
np_10	16.741	0.976
ritm_ecg_p_02	-0.783	0.153

Final Model – Admission

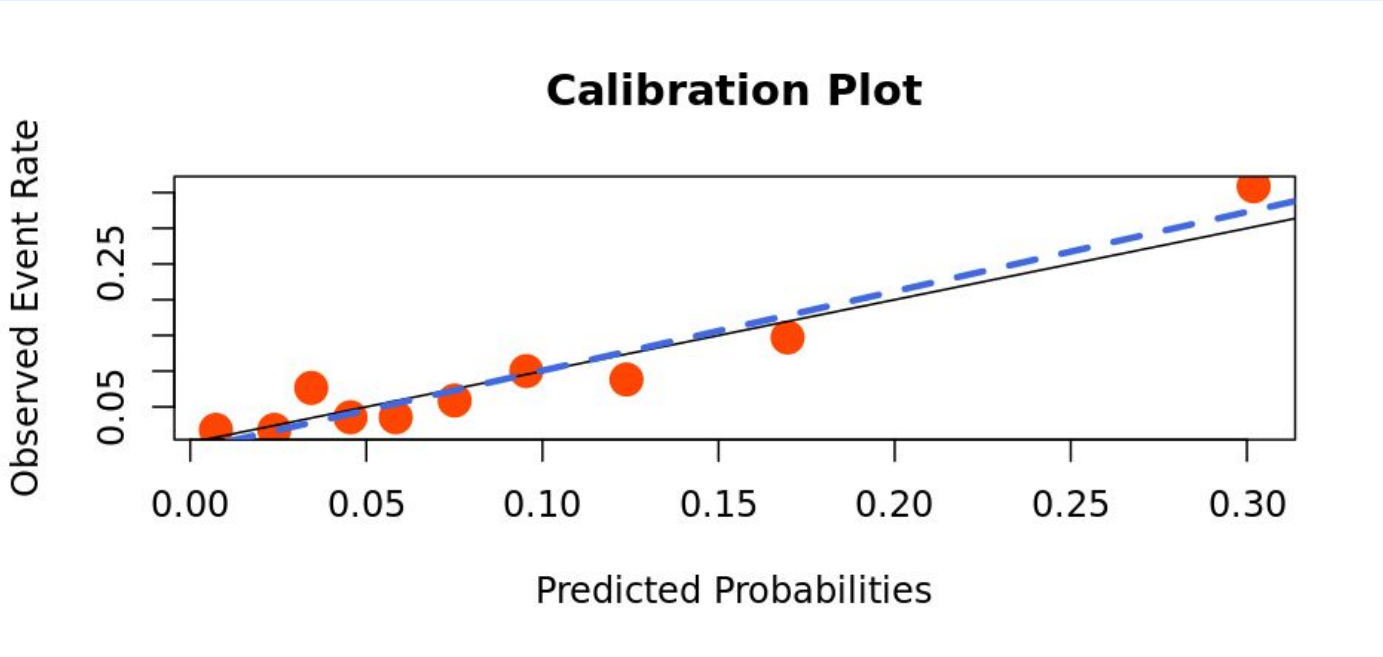


Accuracy: 0.90588
AUC: 0.743145

Final Model – Admission



Final Model – Admission



Final Model – Stay

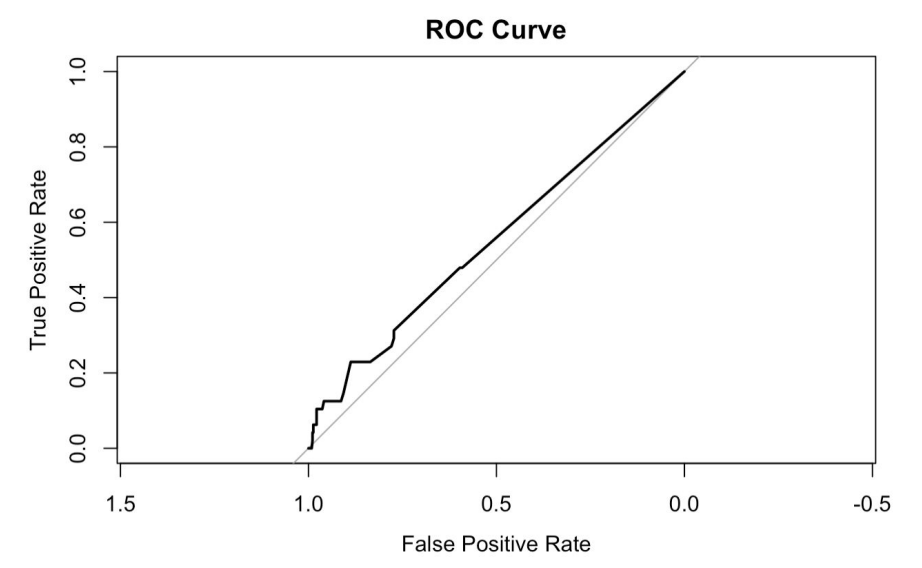
1. Relapse of pain (3rd day)
2. Use of opioid drugs in ICU (1st day)
3. Use of opioid drugs in ICU (2nd day)
4. Use of opioid drugs in ICU (3rd day)

Final Model – Stay

Logistic Regression

	Estimate	Pr(>|z|)
(Intercept)	-2.545	0.000
R_AB_3_n	0.747	0.001
NA_R_1_n	0.168	0.090
NA_R_2_n	0.463	0.014
NA_R_3_n	0.157	0.578

Final Model – Stay



Accuracy: 0.9019
AUC: 0.55028

Conclusions

- Produced 2 models that aims to help doctors identify patients who are at risk of relapse of MI
- Identified important covariates at each time point in the patient trajectory that are important in predicting the relapse of MI

Future Directions

- Use a more recent dataset
- Run more machine learning models
- Test our models on different data

References

Choueiry, George. “Quantifying Health.” *QUANTIFYING HEALTH*, 26 Oct. 2019, quantifyinghealth.com/stepwise-selection/.

“Heart Disease Facts.” *Centers for Disease Control and Prevention*, 15 May 2023, www.cdc.gov/heartdisease/facts.htm.

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Thank You!

Questions?

LINK