

TAVR

Adverse outcomes following Transcatheter Aortic Valve Replacement

Luca Carmisciano (PhD AI)

this work was inspired by the thesis project of Vincenzo De Marzo, MD

Aim

The aim of this project is to explore the feasibility of predicting the all-cause death and major adverse cardiovascular events (MACE) occurring after TAVR procedure, based on baseline patients' characteristics.

We modeled the risks using a large, multicenter, real-world dataset (the TRITAVI registry).

Import, clean, preprocess, describe

'data.frame': 8181 obs. of 59 variables:

```
$ center      : Factor w/ 20 levels "C1","C10"
$ country     : Factor w/ 5 levels "Italy","Sp
$ Age         : num 86 79 81 78 81 84 90 85 8
$ Sex_M       : Factor w/ 2 levels "0","1": 2
$ Weighth_kg  : num 80 85 84 60 70 77 59 70 6
$ bmi         : num 29.4 32 27.4 23.4 24.8 ...
$ Diabetes    : Factor w/ 2 levels "0","1": 1
$ Dyslipidemia : Factor w/ 2 levels "0","1": 2
$ Hypertension : Factor w/ 2 levels "0","1": 2
$ Smoking     : Factor w/ 3 levels "Never","Cu
$ Active_Cancer : Factor w/ 2 levels "0","1": 2
$ Liver_disease : Factor w/ 2 levels "0","1": 1
$ Base_Dialysis : Factor w/ 2 levels "0","1": 1
$ COPD        : Factor w/ 2 levels "0","1": 2
$ PAD         : Factor w/ 2 levels "0","1": 2
$ NYHA_class  : Ord.factor w/ 4 levels "1"<"2"
$ CAD         : Factor w/ 2 levels "0","1": 2
$ Prior_MI    : Factor w/ 2 levels "0","1": 1
$ Prior_PCI   : Factor w/ 2 levels "0","1": 2
$ Prior_CABG  : Factor w/ 2 levels "0","1": 1
$ Prior_CVA   : Factor w/ 2 levels "0","1": 1
$ Base_Aspirin : Factor w/ 2 levels "0","1": 2 2 2 1
$ Base_P2Y12i  : Factor w/ 2 levels "0","1": 2 2 1 1
$ Base_DAPT    : Factor w/ 2 levels "0","1": 2 2 1 1
$ Base_VKA     : Factor w/ 2 levels "0","1": 1 1 1 1
$ Base_NOAC    : Factor w/ 2 levels "0","1": 1 1 1 1
$ STS          : num 13 4 3.4 6.8 4.4 8.5 8 6.6 11.3
$ EuroScore_2  : num 7.6 5.3 6.7 40 8 ...
$ Permanent_PM : Factor w/ 2 levels "0","1": 2 1 1 1
$ Porcelain_Aorta : Factor w/ 2 levels "0","1": 1 1 1 1
$ AF           : Factor w/ 2 levels "0","1": 1 1 1 1
$ Base_EF      : num 48 55 65 35 60 76 55 60 45 52 .
$ Base_EF_class : num 2 1 1 2 1 1 1 2 1 ...
$ Base_Mean_Gradient : num 51 42 45 65 68 53 89 45 47 42 .
$ Base_Creat    : num 0.78 0.89 0.8 1 1.16 0.66 0.76
$ Plts          : num 11.8 12.4 12.1 12.3 11.8 ...
$ Baseline_Hb   : num 10.3 16.7 12.5 9.4 12.9 11.2 11
$ y_of_procedure : num 2018 2018 2018 2018 2018 ...
```

Outcome definition

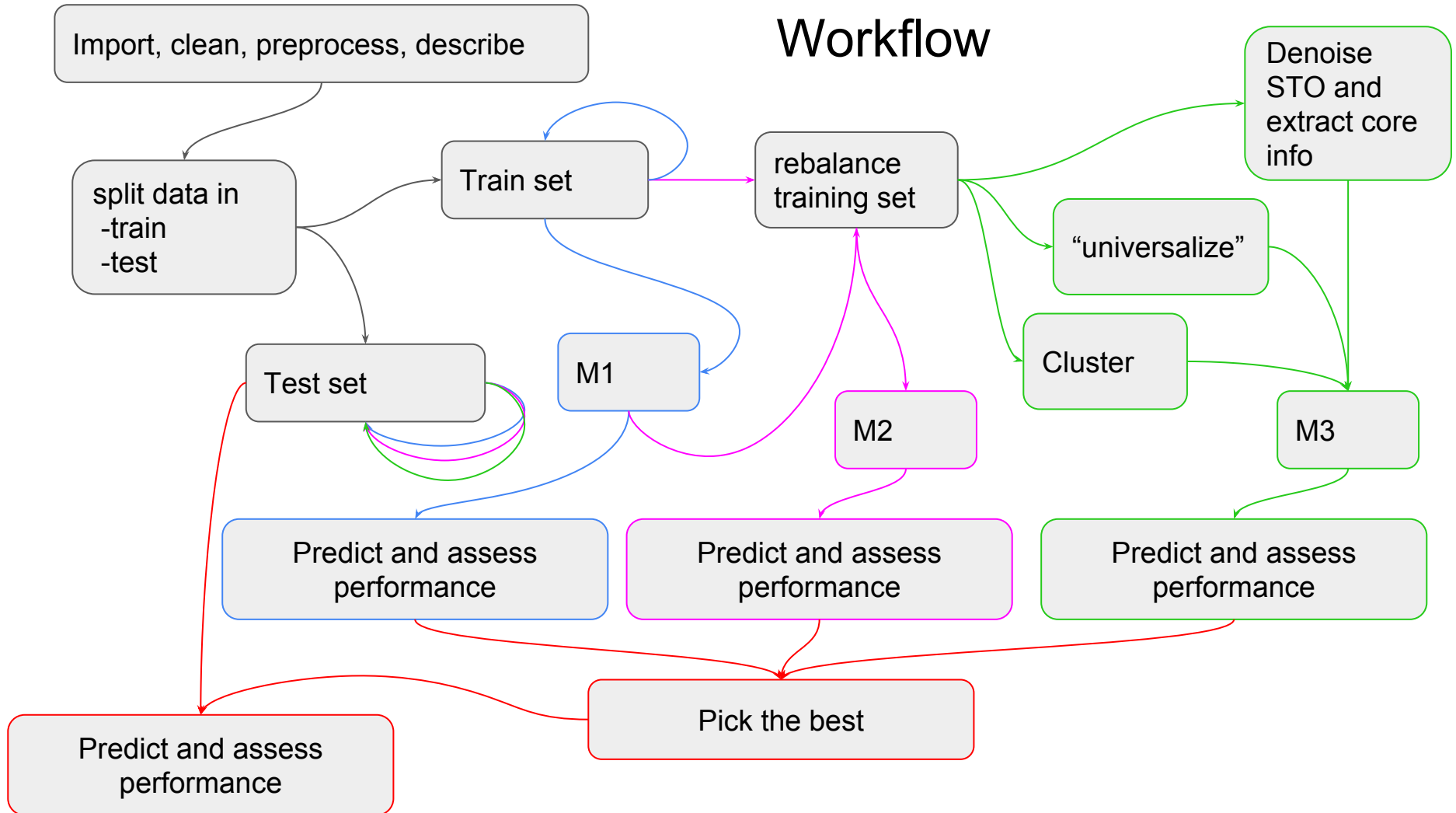
\$ AKIyesno	Factor w/ 2 levels "0","1": 2 2 1 1 2 2 1 2 2 1 ...
\$ AKI23	Factor w/ 2 levels "No","Yes": 2 2 1 1 2 1 1 1 1 1 ...
\$ Creat_increase	num 1.37 10.21 0.01 0.2 2.03 ...
\$ PostProc_Dialysis	Factor w/ 2 levels "0","1": 1 1 1 1 1 1 1 1 1 1 ...
\$ Hb_drop	num -1.4 -2.1 0 -1.6 -6.1 -3.3 0 -3.2 -4.2 -3.6 ...
\$ Transfusion	num 0 0 0 1 1 1 0 1 1 0 ...
\$ Approach_0FEM_1APIC_2OTHERS	num 0 0 0 0 0 0 0 0 0 0 ...
\$ Valve_type	num 2 2 1 2 1 1 1 1 2 2 ...
\$ Valve_Migrat	Factor w/ 2 levels "0","1": 1 1 1 1 1 1 2 1 1 1 ...
\$ Echo_discharge_PVL	num 0 0 0 0 0 1 0 0 2 1 ...
\$ Contrast_Medium	num 150 200 300 100 250 120 350 170 100 80 ...
\$ Final_Mean_Gradient	num 10 7 5 5 4 7 7 5 5 5 ...
\$ Access_Closure_1perc_2surg	Factor w/ 2 levels "1","2": 1 1 1 1 1 1 1 1 1 1 ...
\$ Major_vasc_compl	Factor w/ 2 levels "0","1": 1 1 2 1 1 2 1 1 1 1 ...
\$ Minor_vasc_compl	Factor w/ 2 levels "0","1": 1 1 1 1 1 1 1 2 1 1 ...
\$ bleed	Ord.factor w/ 4 levels "none"<"minor"<..: 2 1 1 1 4 4 :
\$ Hp_stay_dd	num 13 7 5 27 17 37 3 10 20 8 ...
\$ Post therapy	Factor w/ 3 levels "SAPT","DAPT",..: 2 2 1 2 3 1 1 2 3
\$ outcome	Factor w/ 2 levels "FALSE","TRUE": 2 2 2 2 2 2 2 2 1 1
\$ frail	Factor w/ 2 levels "FALSE","TRUE": 1 1 1 1 1 1 1 2 1 1

Imputation

Am I cheating?!

	Out	Will be test
A	0	Y
A	0	N
-	0	Y
A	1	N
B	1	Y
-	1	N
B	1	Y

Workflow



The price of accuracy (M1)

	Reference	
Prediction	FALSE	TRUE
FALSE	3147	1252
TRUE	378	677

Accuracy : 0.7011

95% CI : (0.6888, 0.7133)

No Information Rate : 0.6463

P-Value [Acc > NIR] : < 2.2e-16

Kappa : 0.2716

McNemar's Test P-Value : < 2.2e-16

Sensitivity : 0.8928

Specificity : 0.3510

Pos Pred Value : 0.7154

Neg Pred Value : 0.6417

Subsampling

	Reference	
Prediction	FALSE	TRUE
FALSE	1833	630
TRUE	495	900

And repeat?

Accuracy : 0.7084

95% CI : (0.6938, 0.7227)

No Information Rate : 0.6034

P-Value [Acc > NIR] : < 2.2e-16

Kappa : 0.3814

McNemar's Test P-Value : 6.466e-05

Sensitivity : 0.7874

Specificity : 0.5882

Pos Pred Value : 0.7442

Neg Pred Value : 0.6452

Universal prediction

Coefficients:

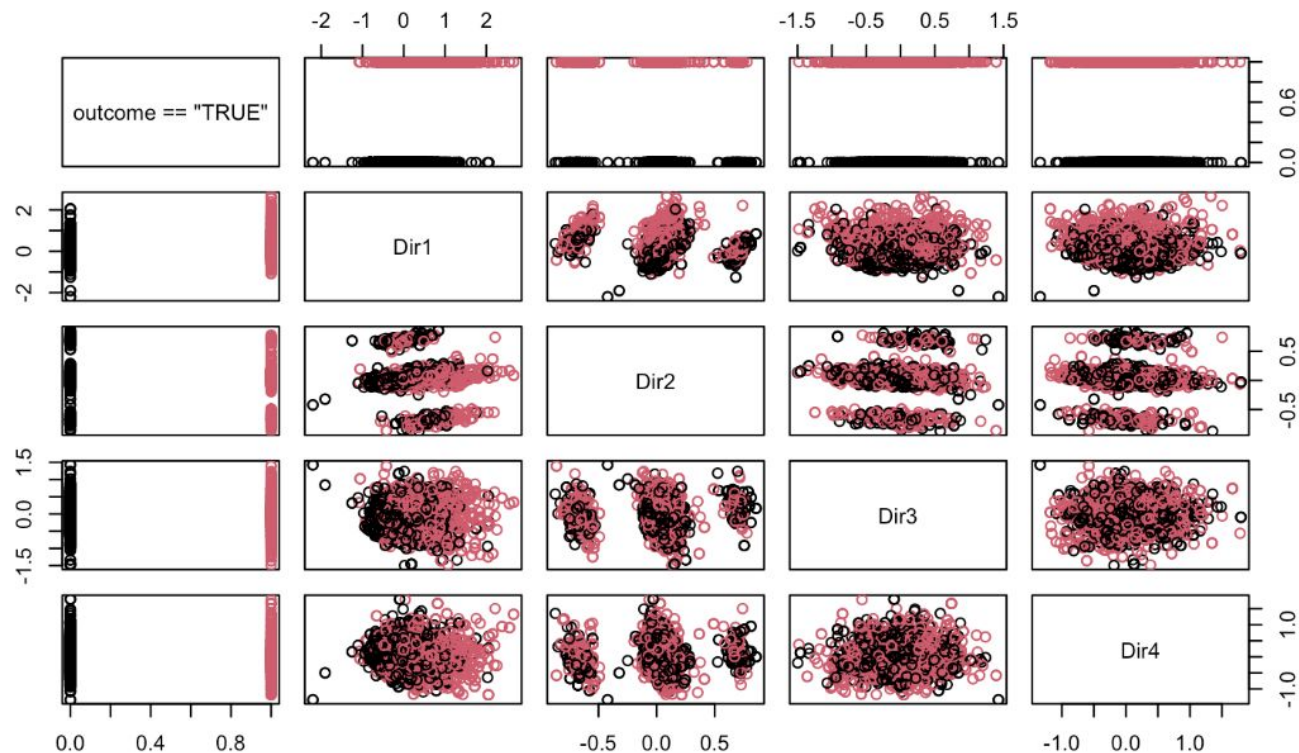
	Estimate	Std. Error	z value	Pr(> z)	
(Intercept)	478.978537	25.132838	19.058	< 2e-16	***
countrySpain	-0.789612	0.199485	-3.958	7.55e-05	***
countryFinland	-0.385048	0.078777	-4.888	1.02e-06	***
countryPoland	-0.097491	0.226648	-0.430	0.667093	
countryEngland	0.317547	0.160909	1.973	0.048443	*

```

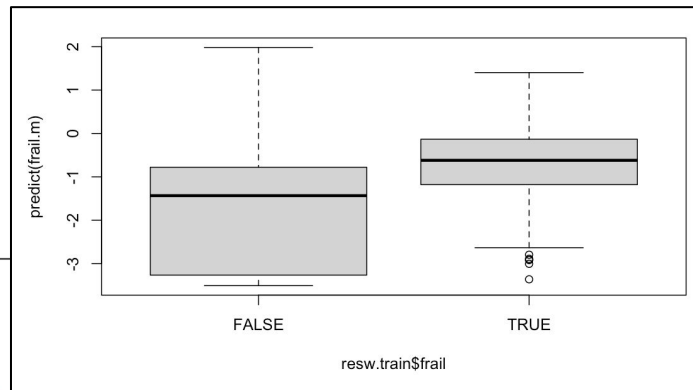
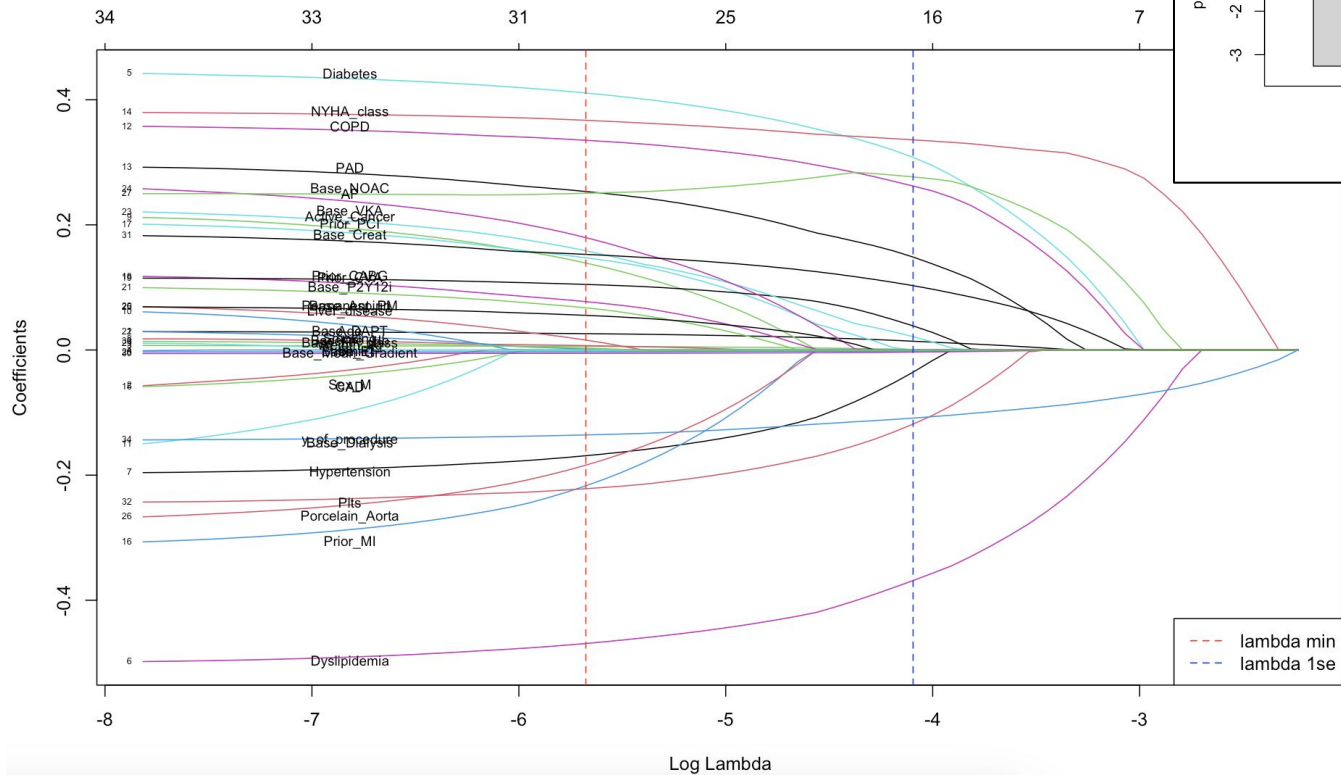
      obs
pred   Italy Spain Finland Poland England Sum
Italy  2865   126    838    114      29 3972
Spain     3     6     1      0       0  10
Finland  288   17   521    10      12  848
Poland   16    0     1    25       0   42
England  60    1    41     3     477  582
Sum     3232  150  1402   152     518 5454
[1] 0.7139714

```

Short term outcomes

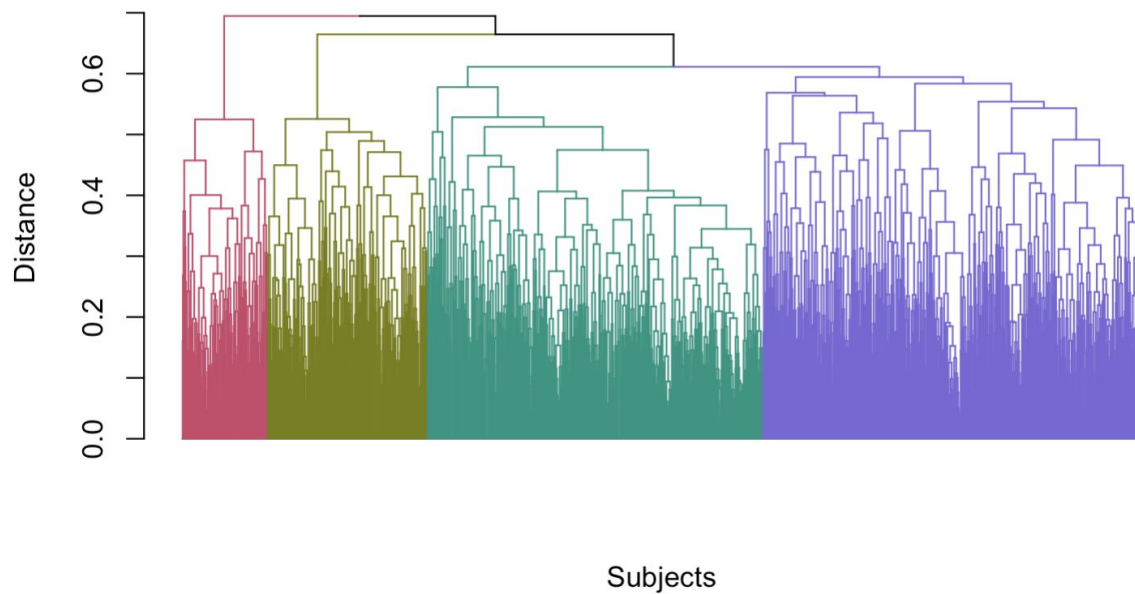


Frailty



Clustering subject Xs

Hierarchical clustering
complete - gower



cluster_k				
	1	2	3	4
1	2479	46	111	30
2	19	489	7	6
3	52	1	248	5
4	46	8	7	304

	1	2	3	4
n	2596	544	373	345
outcome = TRUE (%)	879 (33.9)	289 (53.1)	203 (54.4)	159 (46.1)

M3

Sensitivity	Specificity	Pos Pred Value	Neg Pred Value
Min. :0.7033	Min. :0.5195	Min. :0.7069	Min. :0.5251
1st Qu.:0.7257	1st Qu.:0.5520	1st Qu.:0.7281	1st Qu.:0.5472
Median :0.7310	Median :0.5626	Median :0.7358	Median :0.5578
Mean :0.7316	Mean :0.5617	Mean :0.7359	Mean :0.5563
3rd Qu.:0.7398	3rd Qu.:0.5719	3rd Qu.:0.7439	3rd Qu.:0.5669
Max. :0.7577	Max. :0.5980	Max. :0.7601	Max. :0.5948
Precision	Recall	F1	Prevalence
Min. :0.7069	Min. :0.7033	Min. :0.7138	Min. :0.6029
1st Qu.:0.7281	1st Qu.:0.7257	1st Qu.:0.7262	1st Qu.:0.6185
Median :0.7358	Median :0.7310	Median :0.7347	Median :0.6256
Mean :0.7359	Mean :0.7316	Mean :0.7337	Mean :0.6254
3rd Qu.:0.7439	3rd Qu.:0.7398	3rd Qu.:0.7413	3rd Qu.:0.6315
Max. :0.7601	Max. :0.7577	Max. :0.7518	Max. :0.6483
Detection Rate	Detection Prevalence	Balanced Accuracy	Accuracy
Min. :0.4312	Min. :0.5988	Min. :0.6258	Min. :0.6469
1st Qu.:0.4499	1st Qu.:0.6161	1st Qu.:0.6388	1st Qu.:0.6601
Median :0.4573	Median :0.6221	Median :0.6460	Median :0.6670
Mean :0.4576	Mean :0.6218	Mean :0.6467	Mean :0.6680
3rd Qu.:0.4657	3rd Qu.:0.6272	3rd Qu.:0.6549	3rd Qu.:0.6755
Max. :0.4815	Max. :0.6465	Max. :0.6721	Max. :0.6916
Kappa	AccuracyLower	AccuracyUpper	AccuracyNull
Min. :0.2529	Min. :0.6286	Min. :0.6648	Min. :0.6029
1st Qu.:0.2784	1st Qu.:0.6419	1st Qu.:0.6778	1st Qu.:0.6185
Median :0.2912	Median :0.6490	Median :0.6847	Median :0.6256
Mean :0.2927	Mean :0.6499	Mean :0.6856	Mean :0.6254
3rd Qu.:0.3073	3rd Qu.:0.6575	3rd Qu.:0.6930	3rd Qu.:0.6315
Max. :0.3446	Max. :0.6739	Max. :0.7089	Max. :0.6483
AccuracyPValue	McNemarPValue		
Min. :0.000e+00	Min. :0.009199		
1st Qu.:4.800e-08	1st Qu.:0.183568		
Median :1.639e-06	Median :0.475229		
Mean :7.300e-04	Mean :0.494554		
3rd Qu.:6.575e-05	3rd Qu.:0.795146		
Max. :1.747e-02	Max. :1.000000		

Does it work? Context!

Invasive		TAVI	
LOS	1yMACE	LOS	1yMACE
STS	Euroscore2	?	?

	Pred tavi -	Pred tavi +
Pred inv +		
Pred inv -		