

Risk-Evaluation: Breast Cancer Royston-Altman

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1 Evaluation of RISK survival models

This document highlights the use of

- RRPlot(),
- CoxRiskCalibration(), and
- CalibrationProbPoissonRisk(),

for the evaluation (RRPlot), and calibration of cox models (CoxRiskCalibration) or logistic models (CalibrationProbPoissonRisk) of survival data.

Furthermore, it can be used to evaluate any Risk index that reruns the probability of a future event on external data-set.

This document will use the survival::rotterdam, and survival::gbsg data-sets to train and predict the risk of cancer recurrence after surgery. Both Cox and Logistic models will be trained and evaluated.

Here are some sample plots returned by the evaluated functions:

1.1 The libraries

```
library(survival)
library(FRESA.CAD)

## Loading required package: Rcpp
## Loading required package: stringr
## Loading required package: miscTools
## Loading required package: Hmisc
```

```

## 
## Attaching package: 'Hmisc'
## The following objects are masked from 'package:base':
## 
##     format.pval, units
## Loading required package: pROC
## Type 'citation("pROC")' for a citation.
## 
## Attaching package: 'pROC'
## The following objects are masked from 'package:stats':
## 
##     cov, smooth, var
op <- par(no.readonly = TRUE)
pander::panderOptions('digits', 3)
pander::panderOptions('table.split.table', 400)
pander::panderOptions('keep.trailing.zeros',TRUE)

```

1.2 Breast Cancer Royston-Altman data

1.2.1 data(gbsg, package="survival") and data(rotterdam, package="survival")

```

gbsgdata <- gbsg
rownames(gbsgdata) <- gbsgdata$pid
gbsgdata$pid <- NULL

odata <- rotterdam
rownames(odata) <- odata$pid
odata$pid <- NULL
odata$rfstime <- odata$rtime
odata$status <- odata$recur
odata$rtime <- NULL
odata$recur <- NULL

odata <- odata[, colnames(odata) %in% colnames(gbsgdata)]

odata$size <- 10*(odata$size=="<=20") +
  35*(odata$size=="20-50") +
  60*(odata$size==">50")

data <- as.data.frame(model.matrix(Surv(rfstime, status)~.*., odata))

data$`(Intercept)` <- NULL

dataBrestCancerTrain <- cbind(time=odata[rownames(data), "rfstime"], status=odata[rownames(data), "status"])

colnames(dataBrestCancerTrain) <- str_replace_all(colnames(dataBrestCancerTrain), ":", "_")
colnames(dataBrestCancerTrain) <- str_replace_all(colnames(dataBrestCancerTrain), " ", "")
colnames(dataBrestCancerTrain) <- str_replace_all(colnames(dataBrestCancerTrain), "\\", "_")
colnames(dataBrestCancerTrain) <- str_replace_all(colnames(dataBrestCancerTrain), "-", "_")
colnames(dataBrestCancerTrain) <- str_replace_all(colnames(dataBrestCancerTrain), ">", "_")
dataBrestCancerTrain$time <- dataBrestCancerTrain$time/365 ## To years

```

```
pander::pander(table(odata[rownames(data), "status"]), caption="rotterdam")
```

Table 1: rotterdam

	0	1
	1464	1518

1.2.2 data(gbsg, package="survival") data conditioning

```
gbsgdata <- gbsgdata[, colnames(odata)]
data <- as.data.frame(model.matrix(Surv(rfstime, status) ~ ., gbsgdata))

data$`(`Intercept)`` <- NULL

dataBreastCancerTest <- cbind(time=gbsgdata[rownames(data), "rfstime"], status=gbsgdata[rownames(data), "status"])

colnames(dataBreastCancerTest) <- str_replace_all(colnames(dataBreastCancerTest), ":", "_")
colnames(dataBreastCancerTest) <- str_replace_all(colnames(dataBreastCancerTest), " ", "")
colnames(dataBreastCancerTest) <- str_replace_all(colnames(dataBreastCancerTest), "\\.", "_")
colnames(dataBreastCancerTest) <- str_replace_all(colnames(dataBreastCancerTest), "-", "_")
colnames(dataBreastCancerTest) <- str_replace_all(colnames(dataBreastCancerTest), ">", "_")
dataBreastCancerTest$time <- dataBreastCancerTest$time/365

pander::pander(table(odata[rownames(data), "status"]), caption="gbsg")
```

Table 2: gbsg

	0	1
	499	183

1.3 Cox Modeling

```
ml <- BSWiMS.model(Surv(time, status) ~ ., data=dataBreastCancerTrain, loops=1, NumberofRepeats = 5)

sm <- summary(ml)
pander::pander(sm$coefficients)
```

	Estimate	lower.HR	upper.HR	Accuracy	Auc	Accurately	AUC	CAUC	full.AUC	IDI	NRI	z.IDI	z.NRI	Delta.AUC	Frequency	
age_nodes	2.6e- 04	1.001	1.001	0.626	0.601	0.633	0.630	0.602	0.634	0.0283	3042972	22.26	13.41	5.21e- 02	1.0	
size_grade	1.02e- 03	1.005	1.005	1.006	0.598	0.624	0.633	0.599	0.627	0.635	0.0178	7637163	3.49	10.72	0.767	1.0
nodes	8.25e- 02	1.077	1.086	1.095	0.637	0.642	0.643	0.640	0.644	0.644	0.0073	4406898	2.25	2.000	6.04e- 05	1.0
size	6.77e- 03	1.005	1.007	1.009	0.595	0.641	0.643	0.595	0.642	0.644	0.0137	4233847	7.79	9.406	1.39e- 03	1.0

	Estimate	lower HR	upper HR	Accuracy	AUC	full.AUC	IDI	NRI	z.IDI	z.NRI	Delta.AUC	AUC	Frequency		
size_nodes	1.000	1.000	1.000	0.624	0.643	0.643	0.629	0.644	0.644	0.0034453424	7.24	9.559	-	1.0	
	3.61e-04											3.56e-04			
age_pgr	-4.02e-06	1.000	1.000	0.548	0.631	0.635	0.544	0.634	0.637	0.0092101898	5.33	5.482	3.16e-03	0.2	
													0.03		
grade	1.97e-01	1.138	1.218	1.303	0.565	0.638	0.643	0.561	0.639	0.644	0.0090512018	5.83	6.161	5.02e-03	1.0
													0.03		
age_size	-1.23e-04	1.000	1.000	1.000	0.567	0.629	0.633	0.568	0.632	0.634	0.0059901884	5.63	5.214	2.53e-03	1.0
													0.03		
age	-2.97e-03	0.996	0.997	0.998	0.513	0.628	0.643	0.513	0.628	0.644	0.0041650923	5.27	2.525	1.55e-02	1.0
													0.02		
grade_nodes	0.982	0.987	0.992	0.635	0.645	0.643	0.639	0.646	0.644	0.002028	4.95	-	-	1.0	
	1.31e-02										0.09046		2.532	2.68e-03	
grade_pgr	-0.96e-05	1.000	1.000	1.000	0.541	0.633	0.635	0.537	0.636	0.637	0.0047522652	4.83	7.348	1.01e-03	0.2
													0.03		
size_pgr	1.22e-06	1.000	1.000	1.000	0.490	0.633	0.635	0.494	0.635	0.637	0.0021020162	3.82	0.452	1.62e-03	0.2
													0.03		
meno_nodes	0.996	0.997	0.999	0.580	0.635	0.635	0.584	0.637	0.637	0.0017350073	3.49	0.205	-	0.2	
	2.80e-03												5.37e-04		
meno_pgr	-0.3e-05	1.000	1.000	1.000	0.527	0.634	0.635	0.522	0.636	0.637	0.0025190678	3.30	1.862	4.64e-04	0.2
													0.04		
age_grade	-8.79e-05	1.000	1.000	1.000	0.508	0.632	0.635	0.509	0.634	0.637	0.0008010713	2.42	1.951	2.66e-03	0.2
													0.03		

1.4 Cox Model Performance

Here we evaluate the model using the RRPlot() function.

1.4.1 The evaluation of the raw Cox model with RRPlot()

Here we will use the predicted event probability assuming a baseline hazard for events within 5 years

```
timeinterval <- 5 # Five years
```

```
h0 <- sum(dataBrestCancerTrain$status & dataBrestCancerTrain$time <= timeinterval)
h0 <- h0/sum((dataBrestCancerTrain$time > timeinterval) | (dataBrestCancerTrain$status==1))

pander::pander(t(c(h0=h0,timeinterval=timeinterval)),caption="Initial Parameters")
```

Table 4: Initial Parameters

h0	timeinterval
0.429	5

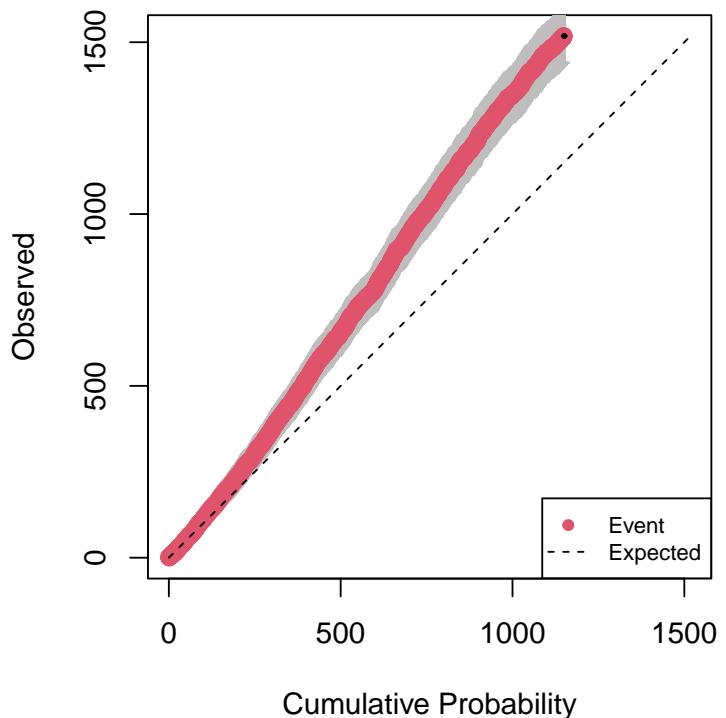
```

index <- predict(ml,dataBreastCancerTrain)
rdata <- cbind(dataBreastCancerTrain$status,ppoisGzero(index,h0))

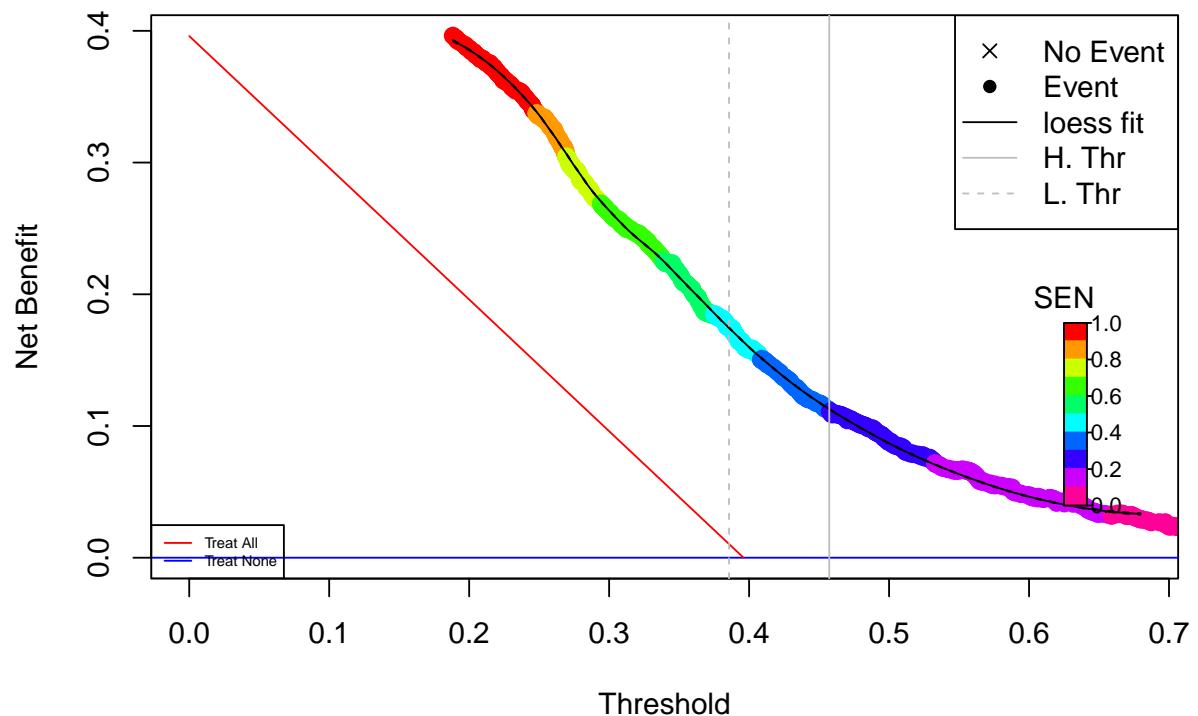
rrAnalysisTrain <- RRPlot(rdata,atRate=c(0.90,0.80),
                           timetoEvent=dataBreastCancerTrain$time,
                           title="Train: Breast Cancer",
                           ysurvlim=c(0.00,1.0),
                           riskTimeInterval=timeinterval)

```

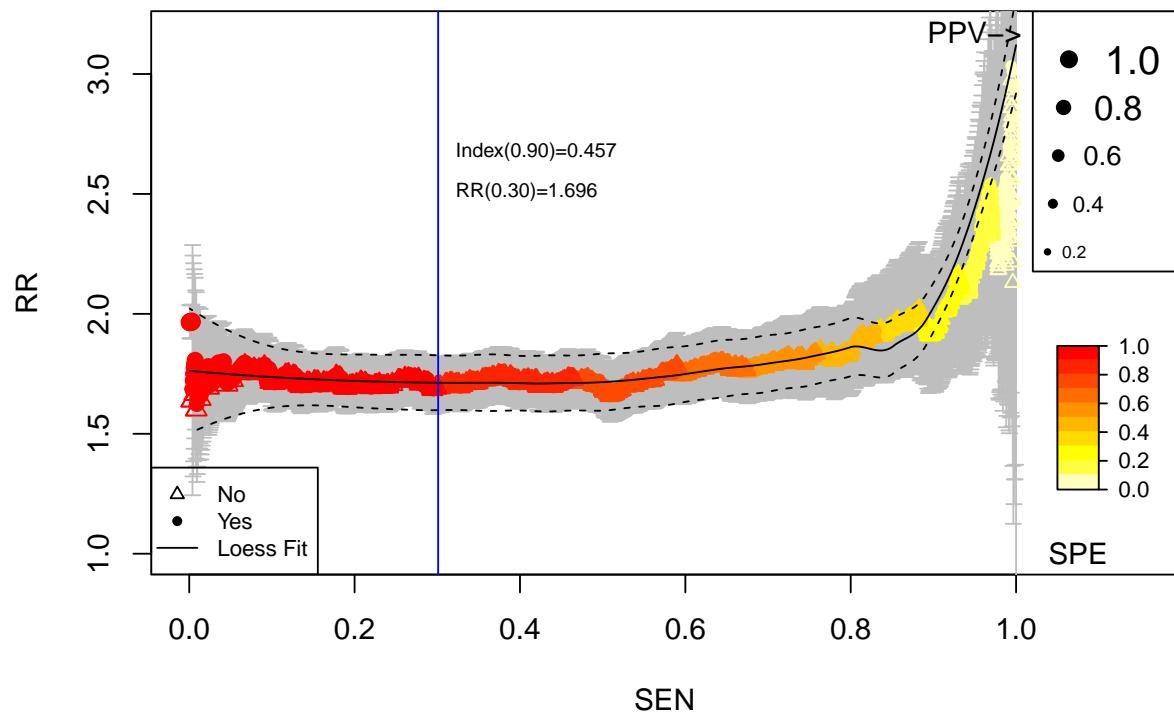
Cumulative vs. Observed: Train: Breast Cancer



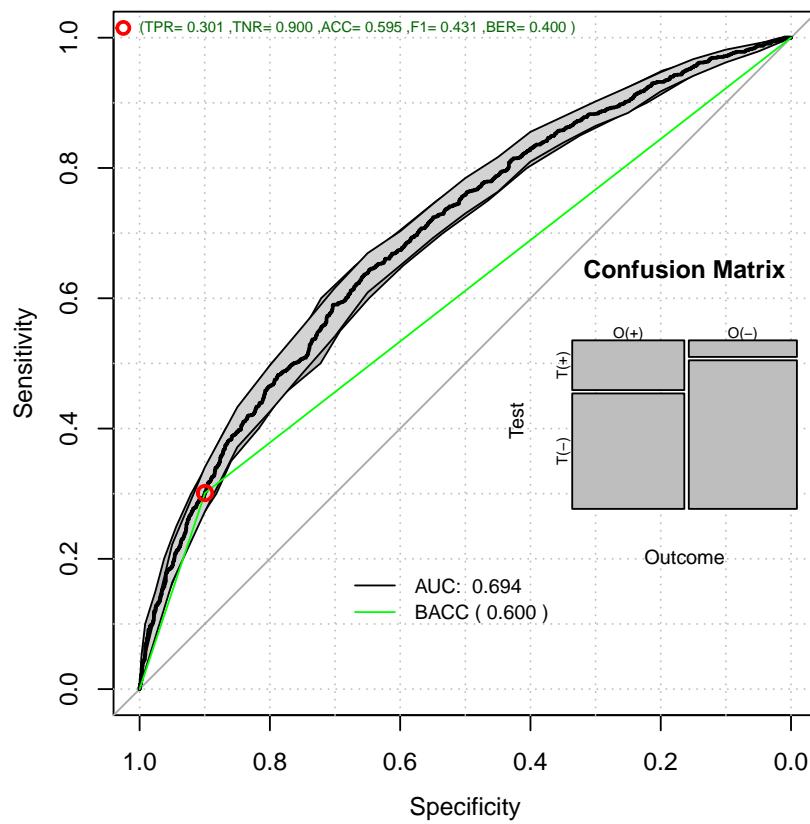
Decision Curve Analysis: Train: Breast Cancer



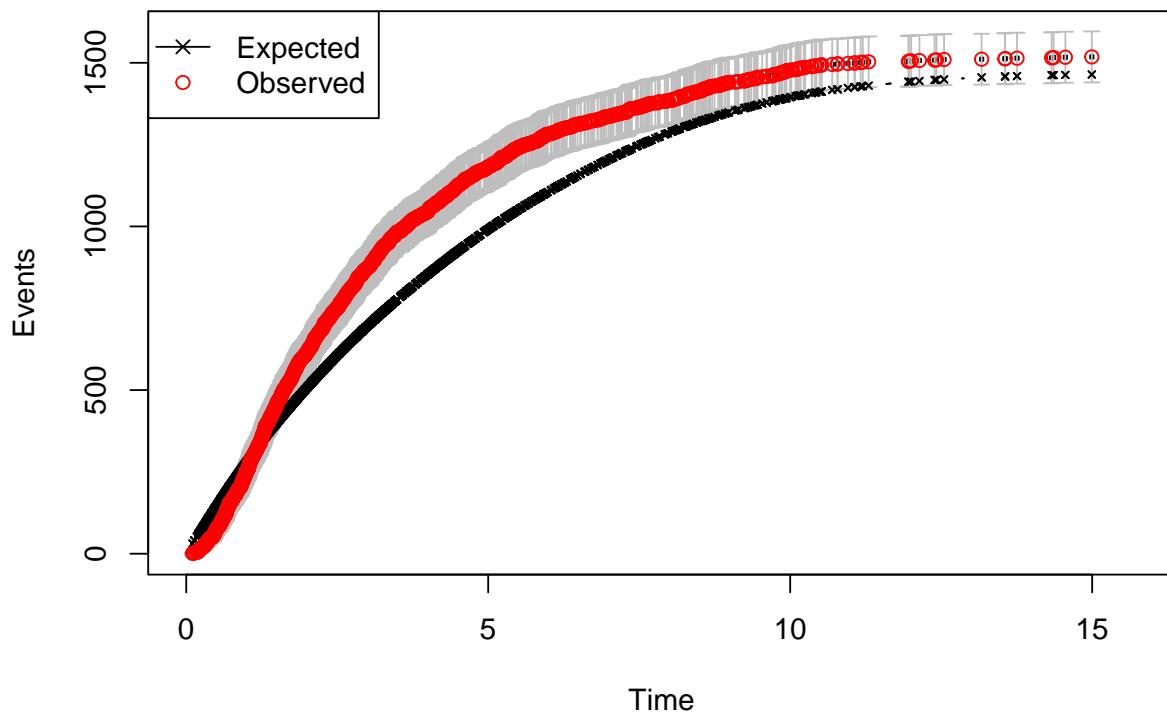
Relative Risk: Train: Breast Cancer



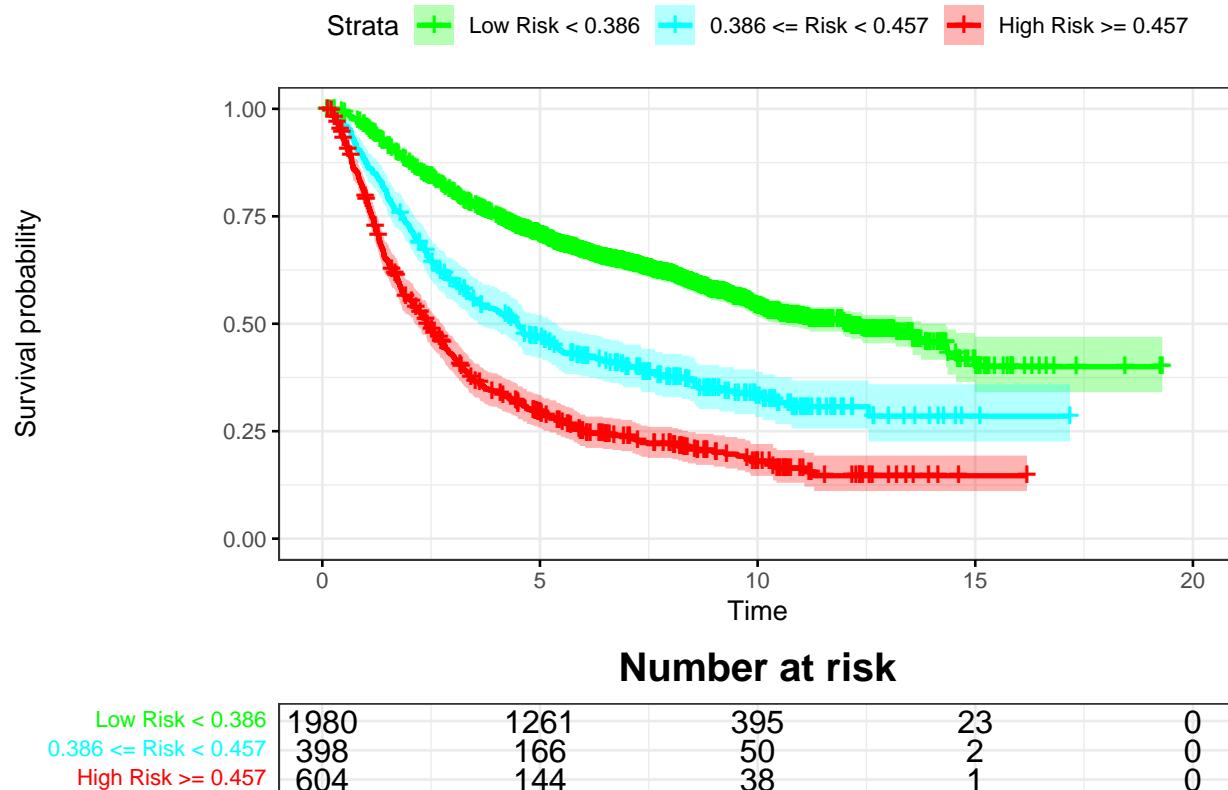
ROC: Train: Breast Cancer



Time vs. Events: Train: Breast Cancer



Kaplan–Meier: Train: Breast Cancer



1.4.2 Time to event

```

toinclude <- rdata[,1]==1
obstiemToEvent <- dataBrestCancerTrain[,"time"]
tmin<-min(obstiemToEvent)
sum(toinclude)

[1] 1518

timetoEvent <- meanTimeToEvent(rdata[,2],timeinterval)
tmax<-max(c(obstiemToEvent,timetoEvent))
lnotime <- log(obstiemToEvent[toinclude])
lnetime <- log(timetoEvent[toinclude])
lmfit <- lm(lnotime~0+lnetime)
sm <- summary(lmfit)
pander::pander(sm)

```

	Estimate	Std. Error	t value	Pr(> t)
lnetime	0.538	0.0128	42.2	5.4e-258

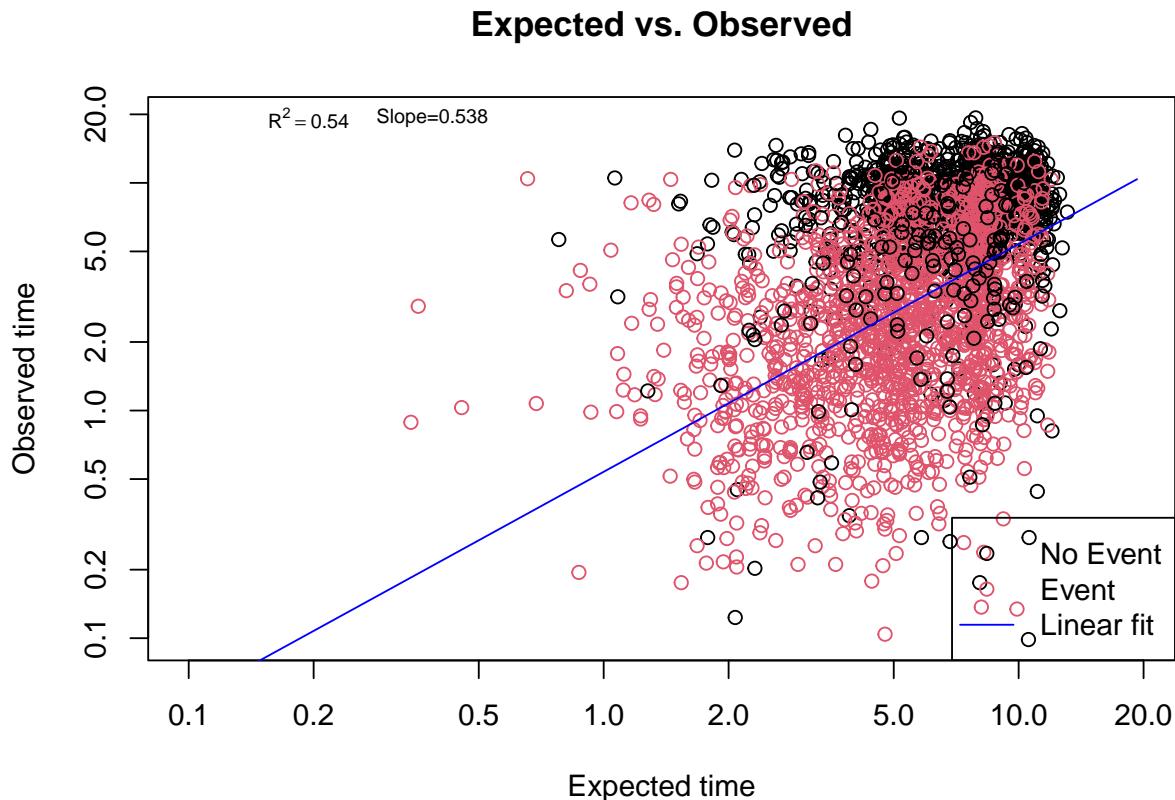
Table 6: Fitting linear model: lnotime \sim 0 + lnetime

Observations	Residual Std. Error	R^2	Adjusted R^2
1518	0.838	0.54	0.54

```

plot(timetoEvent,obstiemToEvent,
  col=1+rdata[,1],
  xlab="Expected time",
  ylab="Observed time",
  main="Expected vs. Observed",
  xlim=c(tmin,tmax),
  ylim=c(tmin,tmax),
  log="xy")
lines(x=c(tmin,tmax),y=lmfit$coefficients*c(tmin,tmax),lty=1,col="blue")
txt <- bquote(R^2 == .(round(sm$r.squared,3)))
text(tmin+0.005*(tmax-tmin),tmax,txt,cex=0.7)
text(tmin+0.015*(tmax-tmin),tmax,sprintf("Slope=%4.3f",sm$coefficients[1]),cex=0.7)
legend("bottomright",legend=c("No Event","Event","Linear fit"),
  pch=c(1,1,-1),
  col=c(1,2,"blue"),
  lty=c(-1,-1,1)
)

```



```
MADerror2 <- mean(abs(timetoEvent[toinclude]-obstiemToEvent[toinclude]))
pander::pander(MADerror2)
```

3.12

The Time vs. Events are not calibrated. Lets do the calibration

1.4.3 Uncalibrated Performance Report

```
pander::pander(t(rrAnalysisTrain$keyPoints),caption="Threshold values")
```

Table 7: Threshold values

	@:0.9	@:0.8	@MAX_BACC	@MAX_RR	@SPE100	p(0.5)
Thr	0.457	0.386	0.345	0.215	1.88e-01	0.4997
RR	1.696	1.723	1.787	2.542	7.67e+01	1.6980
RR_LCI	1.591	1.612	1.662	1.967	1.59e-01	1.5924
RR_UCI	1.807	1.841	1.921	3.285	3.70e+04	1.8107
SEN	0.301	0.466	0.590	0.969	1.00e+00	0.2411
SPE	0.900	0.798	0.704	0.121	1.02e-02	0.9290
BACC	0.600	0.632	0.647	0.545	5.05e-01	0.5850
NetBenefit	0.112	0.175	0.223	0.375	3.96e-01	0.0879

```
pander::pander(t(rrAnalysisTrain$OERatio$estimate),caption="O/E Ratio")
```

Table 8: O/E Ratio

O/E	Low	Upper	p.value
1.04	0.985	1.09	0.158

```
pander::pander(t(rrAnalysisTrain$OE95ci),caption="O/E Mean")
```

Table 9: O/E Mean

mean	50%	2.5%	97.5%
1.14	1.14	1.14	1.15

```
pander::pander(t(rrAnalysisTrain$OAcum95ci),caption="O/Acum Mean")
```

Table 10: O/Acum Mean

mean	50%	2.5%	97.5%
1.32	1.32	1.32	1.32

```
pander::pander(rrAnalysisTrain$c.index$cstatCI,caption="C. Index")
```

mean.C Index	median	lower	upper
0.677	0.677	0.663	0.692

```
pander::pander(t(rrAnalysisTrain$ROCAnalysis$aucs),caption="ROC AUC")
```

Table 12: ROC AUC

est	lower	upper
0.694	0.676	0.713

```
pander::pander((rrAnalysisTrain$ROCAnalysis$sensitivity),caption="Sensitivity")
```

Table 13: Sensitivity

est	lower	upper
0.301	0.278	0.325

```
pander::pander((rrAnalysisTrain$ROCAnalysis$specificity),caption="Specificity")
```

Table 14: Specificity

est	lower	upper
0.9	0.883	0.915

```
pander::pander(t(rrAnalysisTrain$thr_atP),caption="Probability Thresholds")
```

Table 15: Probability Thresholds

90%	80%
0.457	0.386

```
pander::pander(rrAnalysisTrain$surdif,caption="Logrank test")
```

Table 16: Logrank test Chisq = 477.549428 on 2 degrees of freedom,
 $p = 0.000000$

	N	Observed	Expected	$(O-E)^2/E$	$(O-E)^2/V$
class=0	1980	811	1143	96.4	395.1
class=1	398	250	179	28.5	32.4
class=2	604	457	197	345.3	401.9

1.4.4 Cox Calibration

```

op <- par(no.readonly = TRUE)

calprob <- CoxRiskCalibration(ml,dataBrestCancerTrain,"status","time")

pander::pander(c(h0=calprob$h0,
                 Gain=calprob$hazardGain,
                 DeltaTime=calprob$timeInterval),
               caption="Cox Calibration Parameters")

```

h0	Gain	DeltaTime
0.711	1.37	7.16

1.4.5 The RRplot() of the calibrated model

```

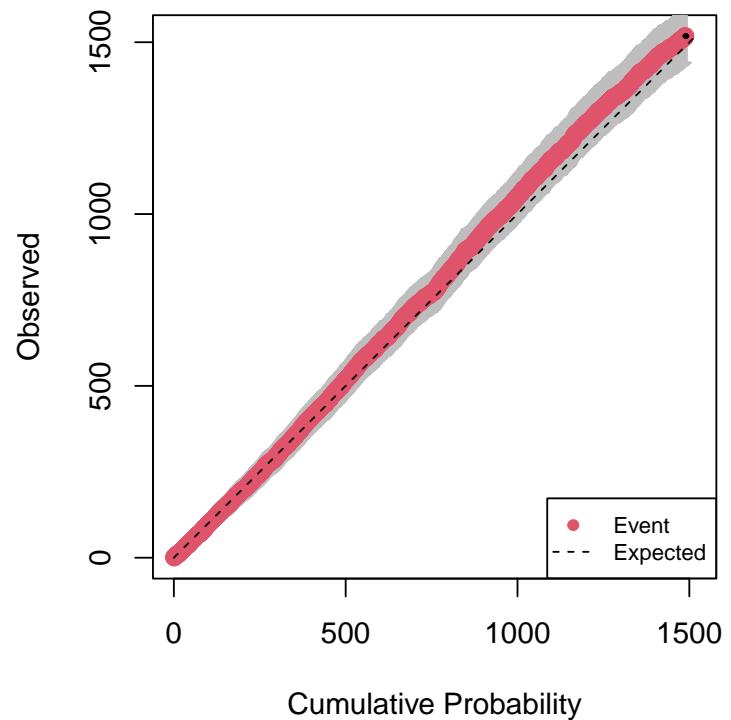
h0 <- calprob$h0
timeinterval <- calprob$timeInterval;

rdata <- cbind(dataBrestCancerTrain$status,calprob$prob)

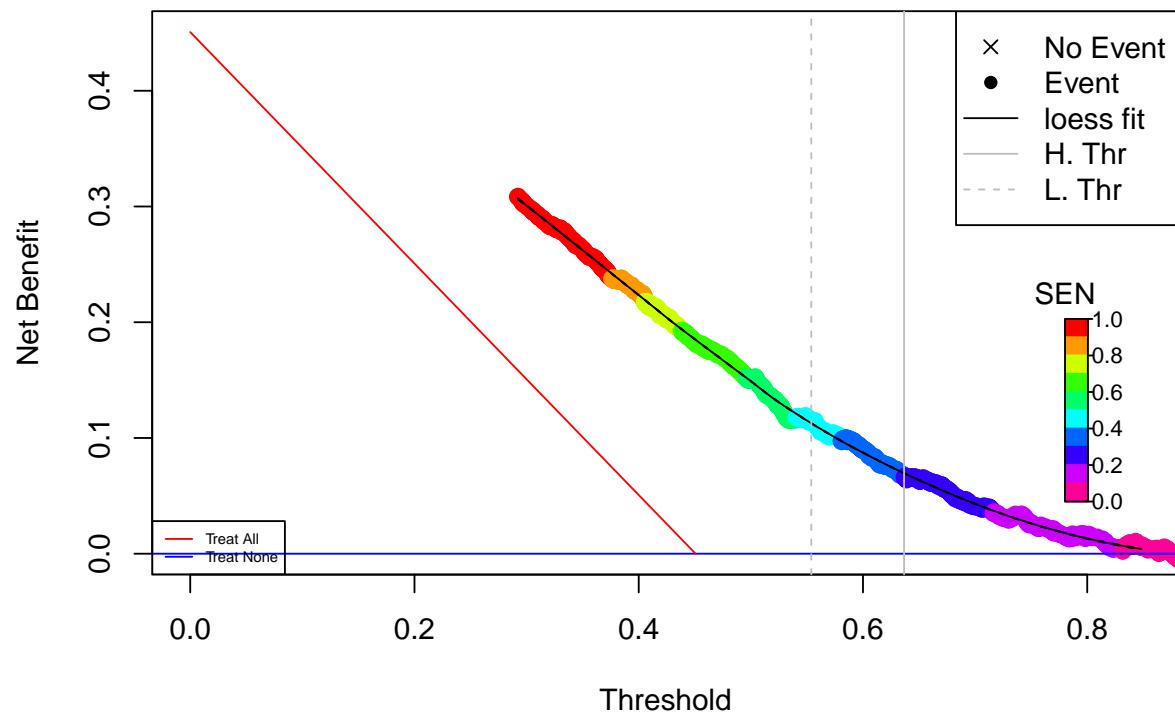
rrAnalysisTrain <- RRPlot(rdata,atRate=c(0.90,0.80),
                           timetoEvent=dataBrestCancerTrain$time,
                           title="Cal. Train: Breast Cancer",
                           ysurvlim=c(0.00,1.0),
                           riskTimeInterval=timeinterval)

```

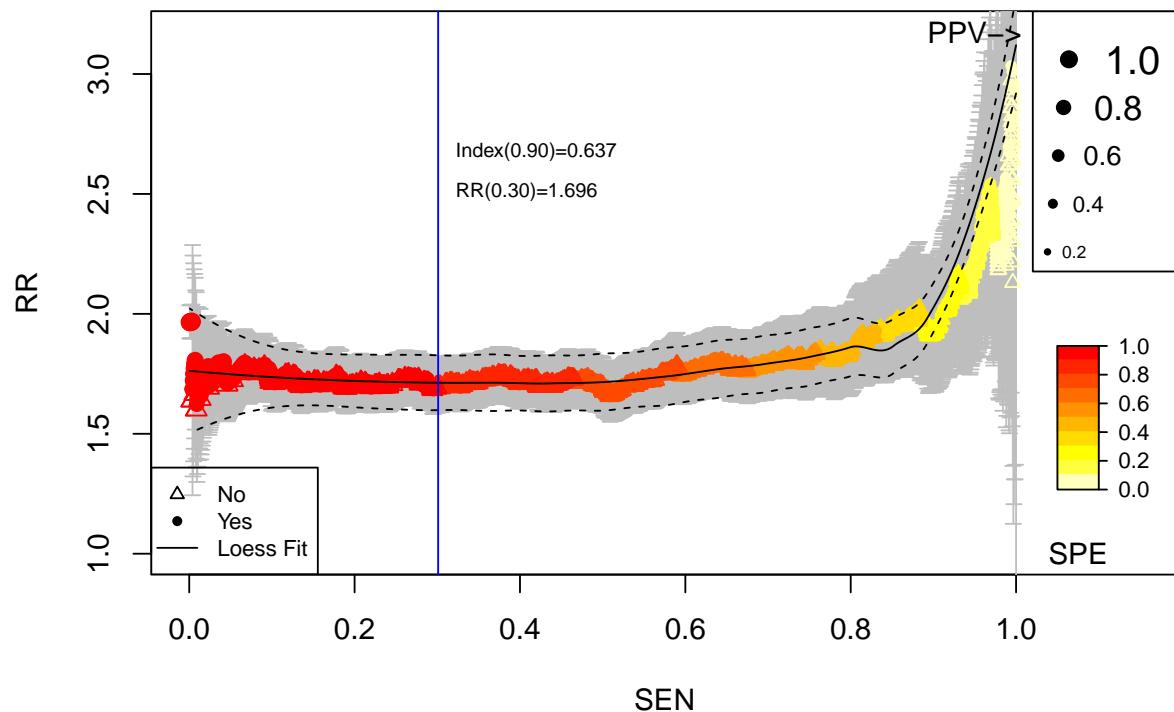
Cumulative vs. Observed: Cal. Train: Breast Cancer



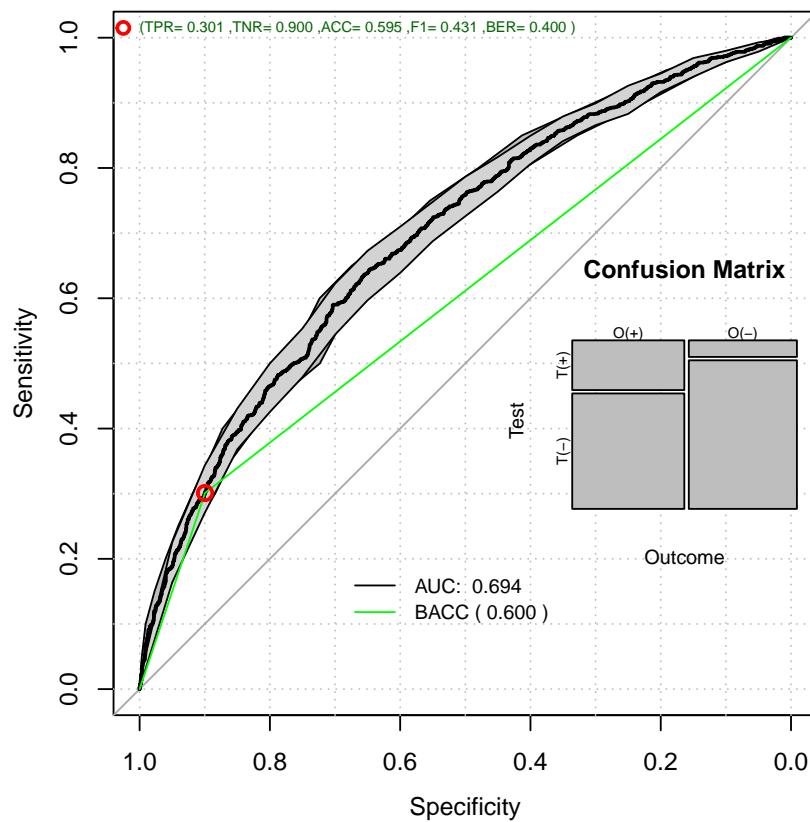
Decision Curve Analysis: Cal. Train: Breast Cancer



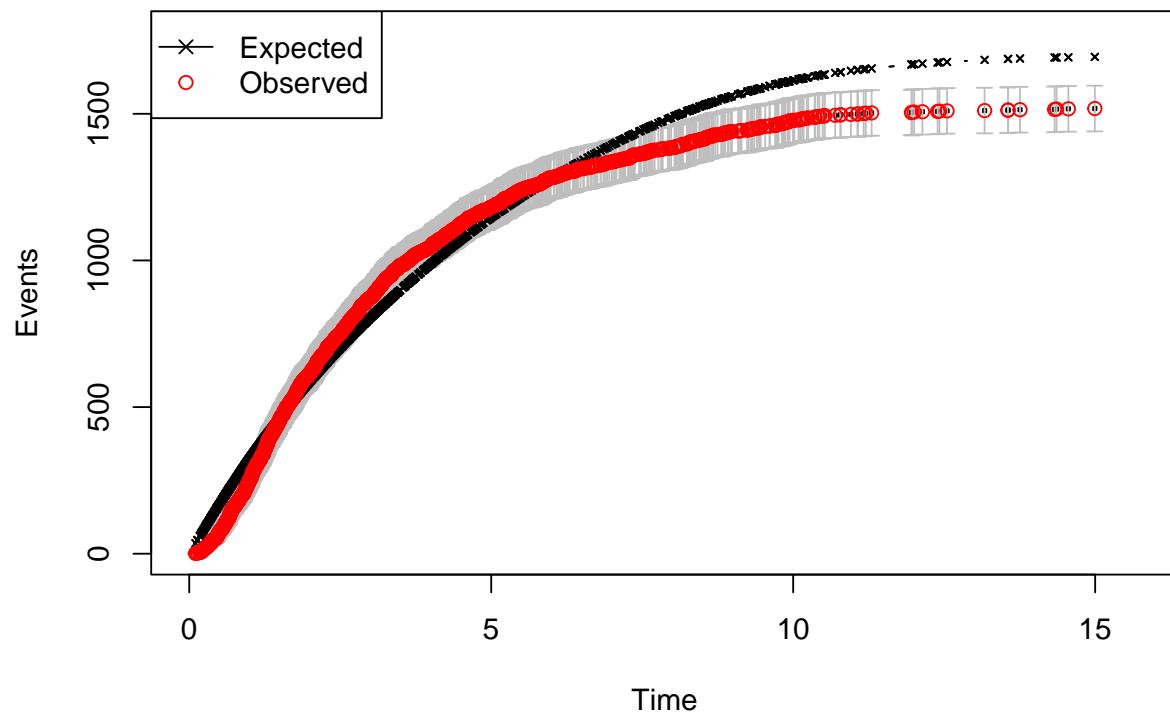
Relative Risk: Cal. Train: Breast Cancer



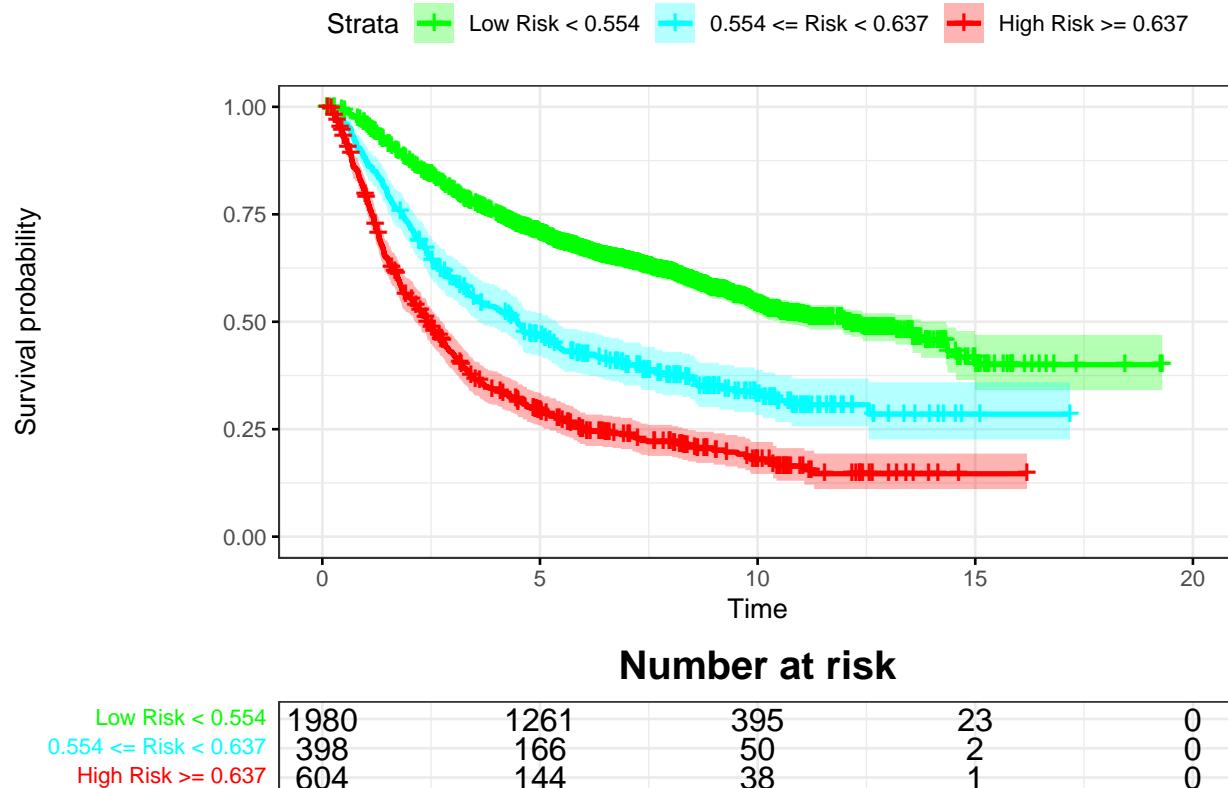
ROC: Cal. Train: Breast Cancer



Time vs. Events: Cal. Train: Breast Cancer



Kaplan–Meier: Cal. Train: Breast Cancer



1.4.6 Time to event after calibration

```
timetoEvent <- meanTimeToEvent(rdata[,2], timeinterval)
tmax<-max(c(obstiemToEvent,timetoEvent))
lnotime <- log(obstiemToEvent[toinclude])
lnetime <- log(timetoEvent[toinclude])
lmfit <- lm(lnotime~0+lnetime)
sm <- summary(lmfit)
pander::pander(sm)
```

	Estimate	Std. Error	t value	Pr(> t)
lnetime	0.586	0.0139	42.1	2.07e-257

Table 19: Fitting linear model: lnotime ~ 0 + lnetime

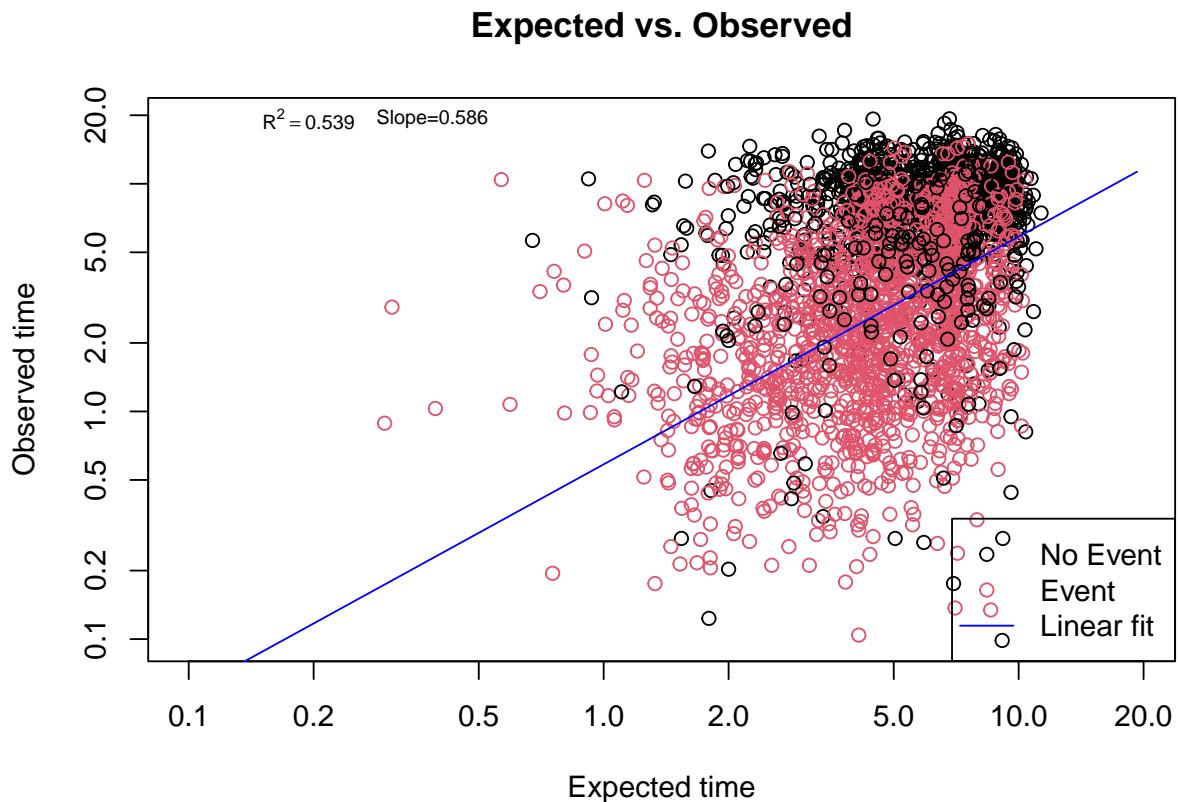
Observations	Residual Std. Error	R ²	Adjusted R ²
1518	0.839	0.539	0.539

```
plot(timetoEvent,obstiemToEvent,
  col=1+rdata[,1],
  xlab="Expected time",
```

```

ylab="Observed time",
main="Expected vs. Observed",
xlim=c(tmin,tmax),
ylim=c(tmin,tmax),
log="xy")
lines(x=c(tmin,tmax),y=lmfit$coefficients*c(tmin,tmax),lty=1,col="blue")
txt <- bquote(paste(R^2 == .(round(sm$r.squared,3))))
text(tmin+0.005*(tmax-tmin),tmax,txt,cex=0.7)
text(tmin+0.015*(tmax-tmin),tmax,sprintf("Slope=%4.3f",sm$coefficients[1]),cex=0.7)
legend("bottomright",legend=c("No Event","Event","Linear fit"),
      pch=c(1,1,-1),
      col=c(1,2,"blue"),
      lty=c(-1,-1,1)
)

```



```

MADerror2 <- c(MADerror2,mean(abs(timetetoEvent[toinclude]-obstiemToEvent[toinclude])))
pander::pander(MADerror2)

```

3.12 and 2.64

1.4.7 Calibrated Train Performance

```
pander::pander(t(rrAnalysisTrain$keyPoints),caption="Threshold values")
```

Table 20: Threshold values

	@:0.9	@:0.8	@MAX_BACC	@MAX_RR	@SPE100	p(0.5)
Thr	0.6367	0.554	0.504	0.330	2.92e-01	0.500
RR	1.6958	1.723	1.787	2.542	7.67e+01	1.758
RR_LCI	1.5912	1.612	1.662	1.967	1.59e-01	1.635
RR_UCI	1.8072	1.841	1.921	3.285	3.70e+04	1.891
SEN	0.3011	0.466	0.590	0.969	1.00e+00	0.594
SPE	0.8996	0.798	0.704	0.121	1.02e-02	0.691
BACC	0.6003	0.632	0.647	0.545	5.05e-01	0.642
NetBenefit	0.0669	0.114	0.152	0.281	3.08e-01	0.151

```
pander::pander(t(rrAnalysisTrain$OERatio$estimate),caption="O/E Ratio")
```

Table 21: O/E Ratio

O/E	Low	Upper	p.value
0.896	0.852	0.942	1.44e-05

```
pander::pander(t(rrAnalysisTrain$OE95ci),caption="O/E Mean")
```

Table 22: O/E Mean

mean	50%	2.5%	97.5%
0.988	0.988	0.982	0.995

```
pander::pander(t(rrAnalysisTrain$OAcum95ci),caption="O/Acum Mean")
```

Table 23: O/Acum Mean

mean	50%	2.5%	97.5%
1.03	1.03	1.03	1.04

```
pander::pander(rrAnalysisTrain$c.index$cstatCI,caption="C. Index")
```

mean.C Index	median	lower	upper
0.677	0.677	0.663	0.69

```
pander::pander(t(rrAnalysisTrain$ROCAalysis$aucs),caption="ROC AUC")
```

Table 25: ROC AUC

est	lower	upper
0.694	0.676	0.713

```
pander::pander((rrAnalysisTrain$ROCAnalysis$sensitivity),caption="Sensitivity")
```

Table 26: Sensitivity

est	lower	upper
0.301	0.278	0.325

```
pander::pander((rrAnalysisTrain$ROCAnalysis$specificity),caption="Specificity")
```

Table 27: Specificity

est	lower	upper
0.9	0.883	0.915

```
pander::pander(t(rrAnalysisTrain$thr_atP),caption="Probability Thresholds")
```

Table 28: Probability Thresholds

90%	80%
0.637	0.554

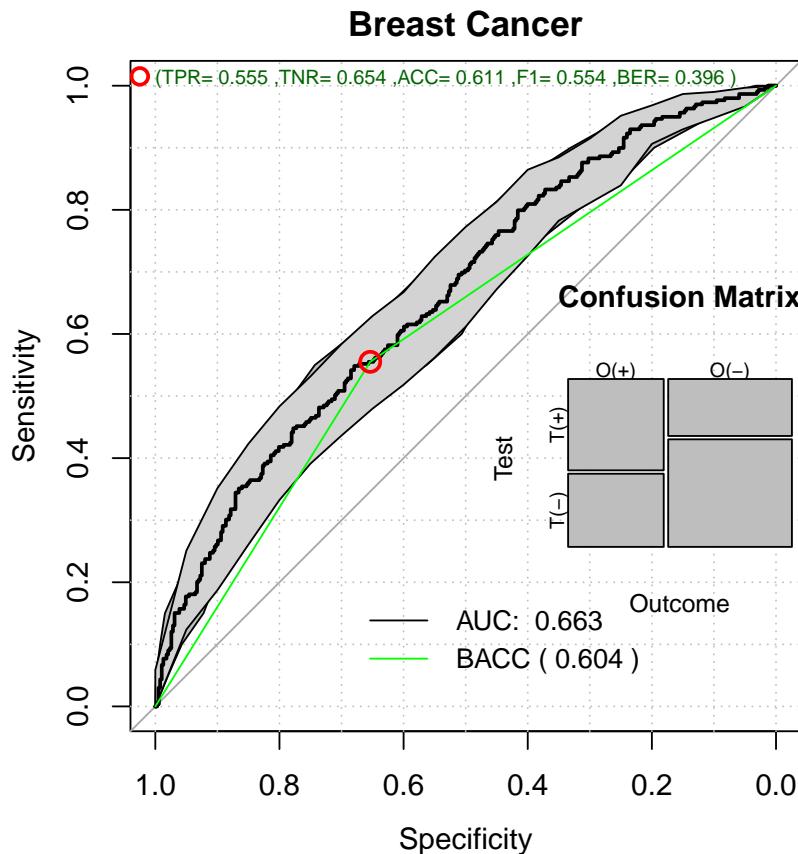
```
pander::pander(rrAnalysisTrain$surdif,caption="Logrank test")
```

Table 29: Logrank test Chisq = 477.549428 on 2 degrees of freedom,
p = 0.000000

	N	Observed	Expected	(O-E)^2/E	(O-E)^2/V
class=0	1980	811	1143	96.4	395.1
class=1	398	250	179	28.5	32.4
class=2	604	457	197	345.3	401.9

1.5 Performance on the external data set

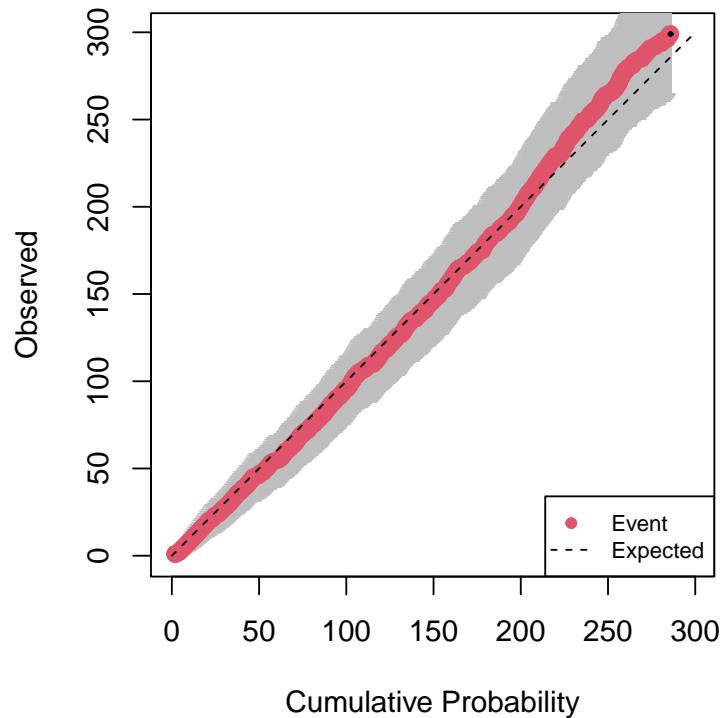
```
index <- predict(ml,dataBrestCancerTest)
pp <- predictionStats_binary(cbind(dataBrestCancerTest$status,index),plotname="Breast Cancer")
```



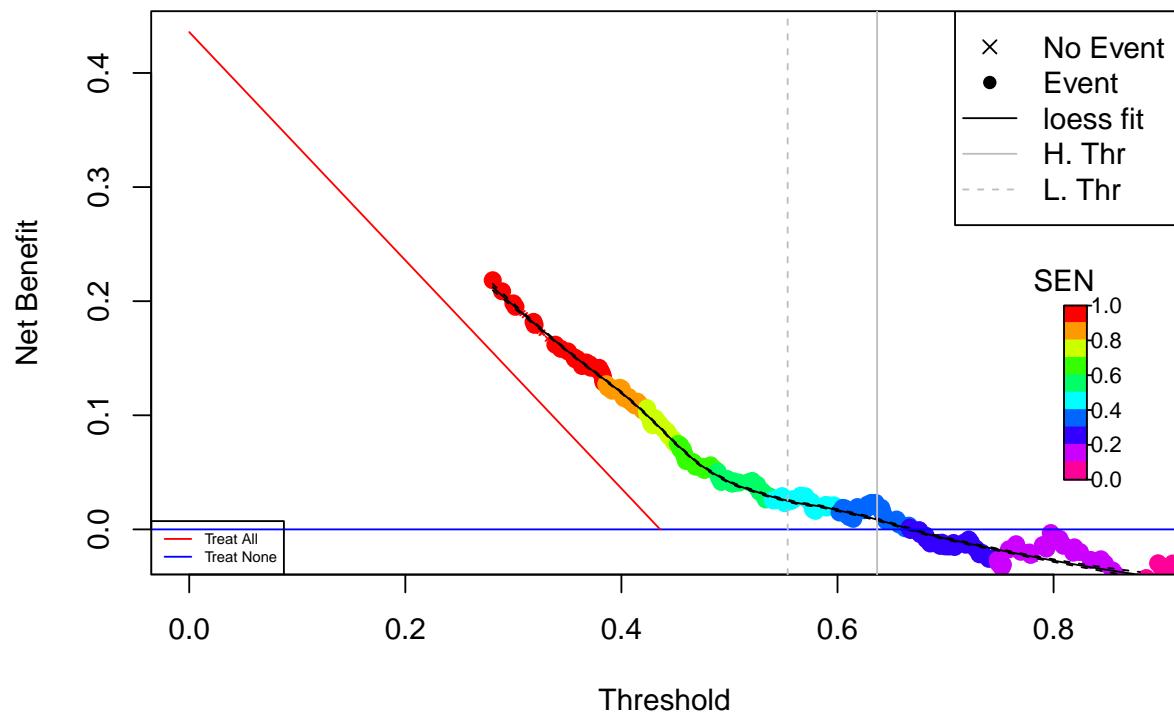
```
par(op)
```

```
prob <- ppoisGzero(index,h0)
rdata <- cbind(dataBrestCancerTest$status,prob)
rrCoxTestAnalysis <- RRPplot(rdata,atThr=rrAnalysisTrain$thr_atP,
                               timetoEvent=dataBrestCancerTest$time,
                               title="Test: Breast Cancer",
                               ysurvlim=c(0.00,1.0),
                               riskTimeInterval=timeinterval)
```

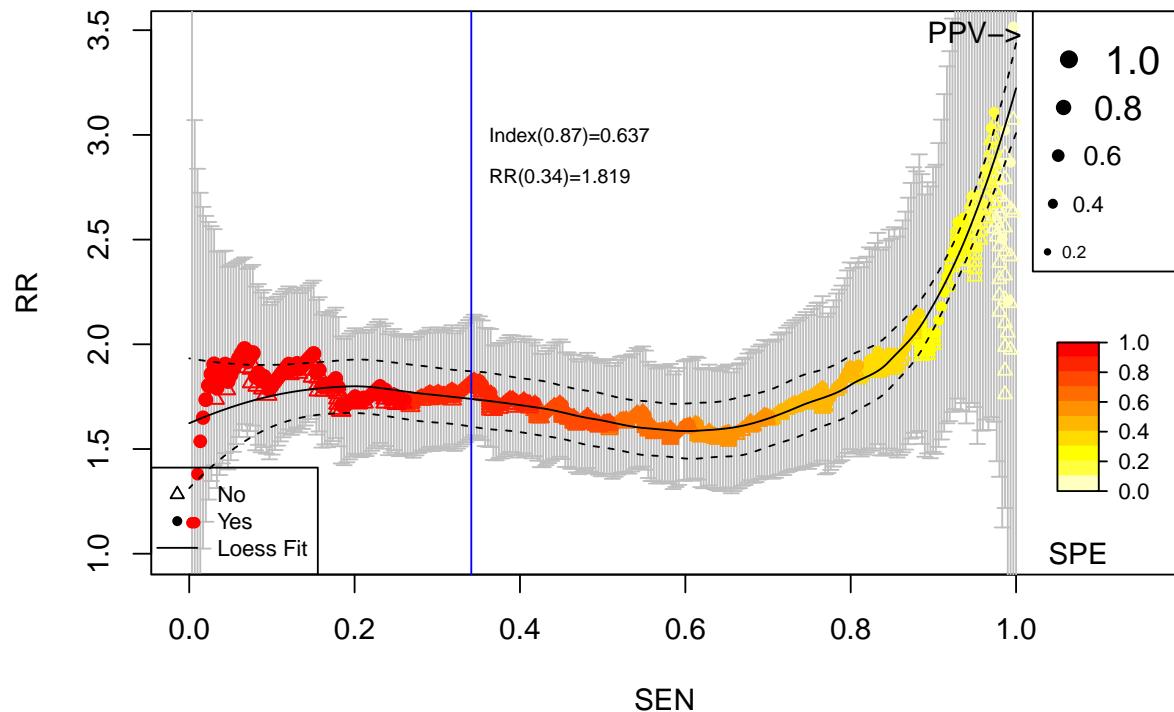
Cumulative vs. Observed: Test: Breast Cancer

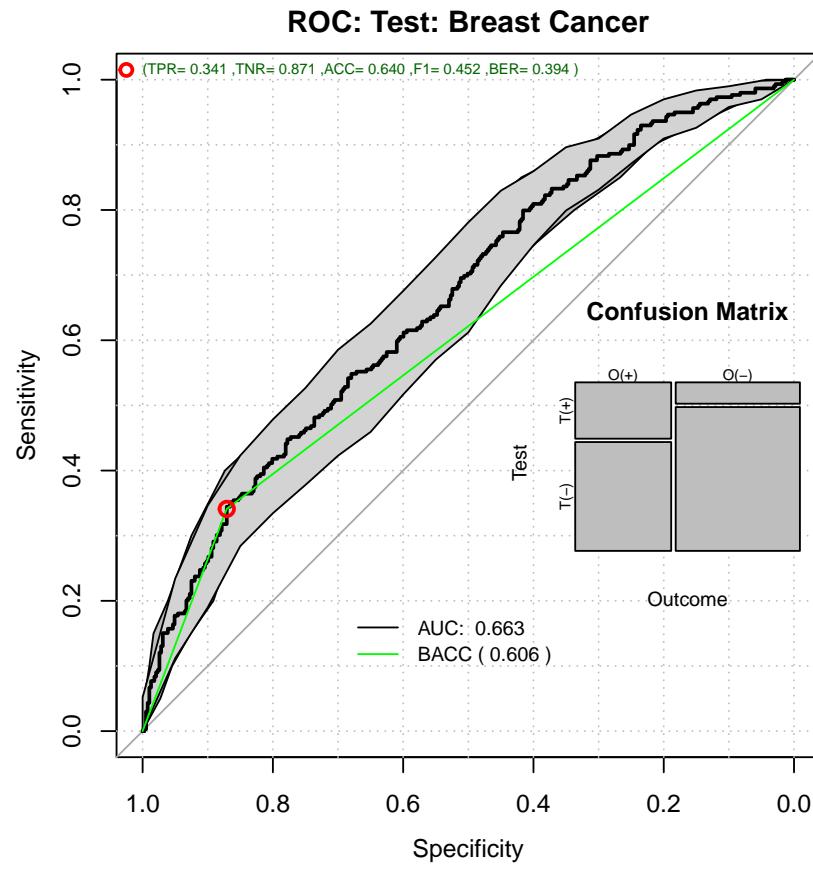


Decision Curve Analysis: Test: Breast Cancer

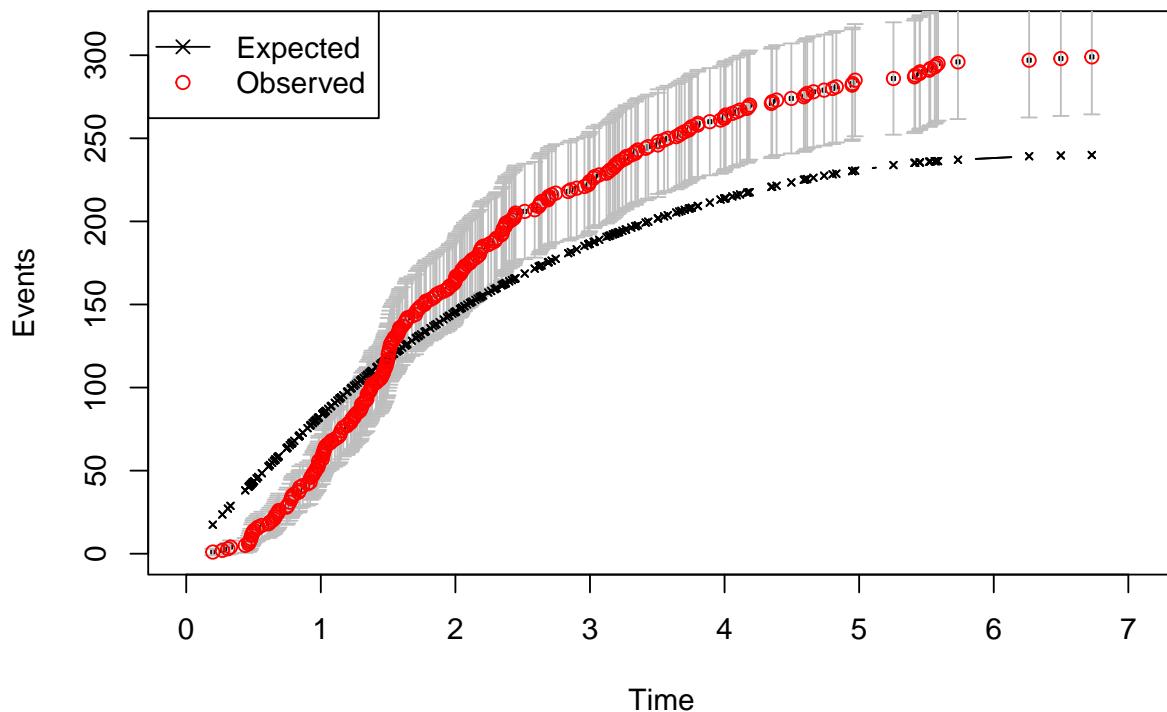


Relative Risk: Test: Breast Cancer

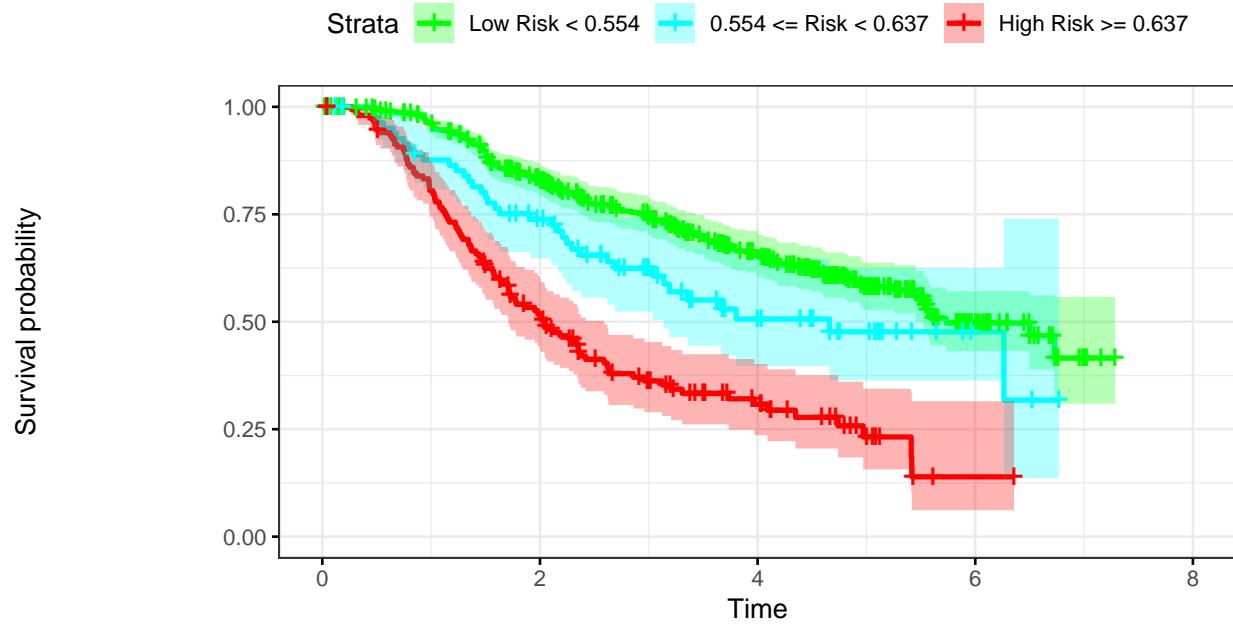




Time vs. Events: Test: Breast Cancer



Kaplan–Meier: Test: Breast Cancer



```
par(op)
```

1.5.1 External Data Report

```
pander::pander(t(rrCoxTestAnalysis$keyPoints), caption="Threshold values")
```

Table 30: Threshold values

	@:0.637	@:0.554	@MAX_BACC	@MAX_RR	@SPE100	p(0.5)
Thr	0.6353	0.5539	0.5211	0.351	2.81e-01	0.5000
RR	1.8307	1.6248	1.6788	3.108	2.20e+01	1.5951
RR_LCI	1.5650	1.3787	1.4164	1.630	4.75e-02	1.3413
RR_UCI	2.1414	1.9149	1.9898	5.925	1.02e+04	1.8969
SEN	0.3445	0.4649	0.5485	0.973	1.00e+00	0.5753
SPE	0.8708	0.7416	0.6796	0.119	1.29e-02	0.6305
BACC	0.6076	0.6032	0.6140	0.546	5.06e-01	0.6029
NetBenefit	0.0232	0.0217	0.0424	0.156	2.18e-01	0.0423

```
pander::pander(t(rrCoxTestAnalysis$OERatio$estimate), caption="O/E Ratio")
```

Table 31: O/E Ratio

O/E	Low	Upper	p.value
1.25	1.11	1.4	0.00023

```
pander::pander(rrCoxTestAnalysis$c.index, caption="C. Index")
```

- **C Index:** 0.666
- **Dxy:** 0.331
- **S.D.:** 0.031
- **n:** 686
- **missing:** 0
- **uncensored:** 299
- **Relevant Pairs:** 266144
- **Concordant:** 177175
- **Uncertain:** 203702
- **cstatCI:**

mean.C Index	median	lower	upper
0.666	0.666	0.636	0.695

```
pander::pander(t(rrCoxTestAnalysis$ROCAccuracy$aucs), caption="ROC AUC")
```

Table 33: ROC AUC

est	lower	upper
0.663	0.622	0.703

```
pander::pander((rrCoxTestAnalysis$ROCAccuracy$sensitivity), caption="Sensitivity")
```

Table 34: Sensitivity

est	lower	upper
0.341	0.288	0.398

```
pander::pander((rrCoxTestAnalysis$ROCAccuracy$specificity), caption="Specificity")
```

Table 35: Specificity

est	lower	upper
0.871	0.833	0.903

```
pander::pander(t(rrCoxTestAnalysis$thr_atP), caption="Probability Thresholds")
```

Table 36: Probability Thresholds

90%	80%
0.637	0.554

```
pander::pander(rrCoxTestAnalysis$surdif, caption="Logrank test")
```

Table 37: Logrank test Chisq = 85.405348 on 2 degrees of freedom,
 $p = 0.000000$

	N	Observed	Expected	$(O-E)^2/E$	$(O-E)^2/V$
class=0	448	160	219.0	15.89	60.334
class=1	86	37	33.9	0.29	0.328
class=2	152	102	46.1	67.59	81.340

1.5.2 Calibrating the index on the test data

```
calprob <- CoxRiskCalibration(ml,dataBrestCancerTest,"status","time")

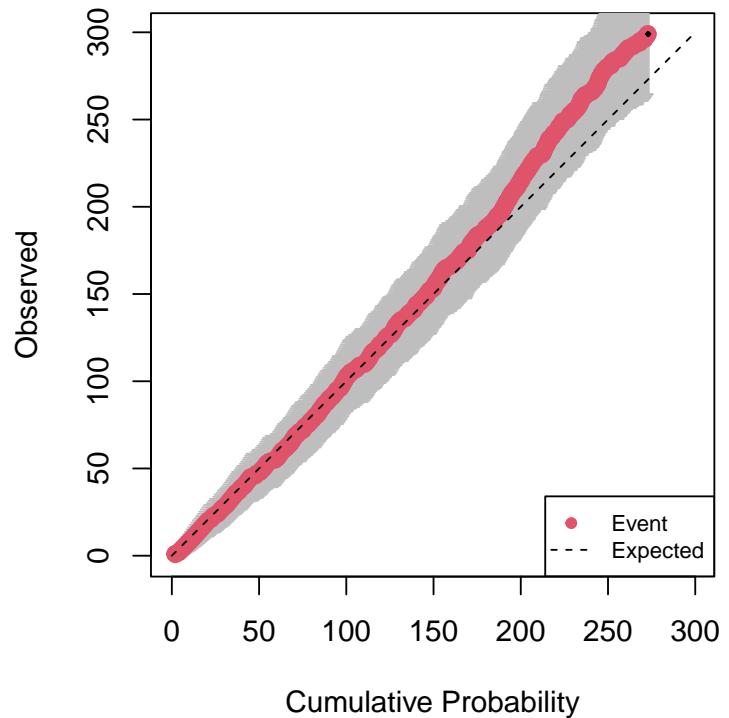
pander::pander(c(h0=calprob$h0,
                 Gain=calprob$hazardGain,
                 DeltaTime=calprob$timeInterval),
               caption="Cox Calibration Parameters")
```

h0	Gain	DeltaTime
0.597	1.03	5.73

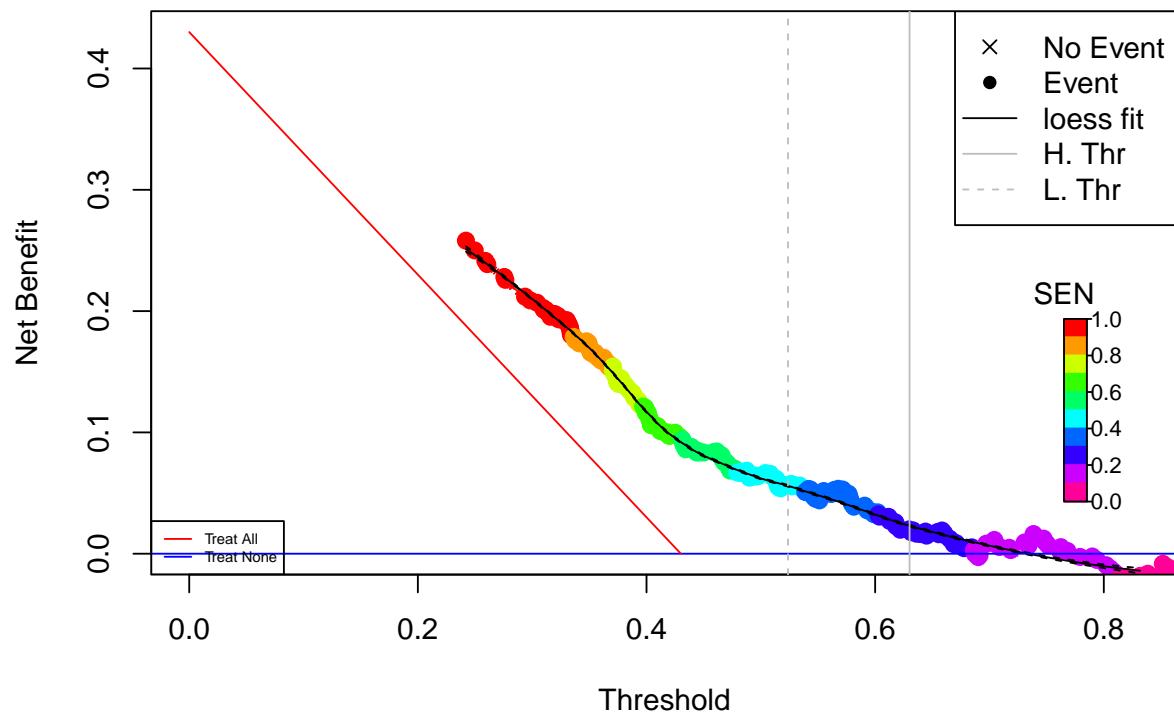
```
rdata <- cbind(dataBrestCancerTest$status,calprob$prob)

rrAnalysis <- RRPlot(rdata,atRate=c(0.90,0.80),
                      timetoEvent=dataBrestCancerTest$time,
                      title="Cal. Test: Breast Cancer",
                      ysurvlim=c(0.00,1.0),
                      riskTimeInterval=calprob$timeInterval)
```

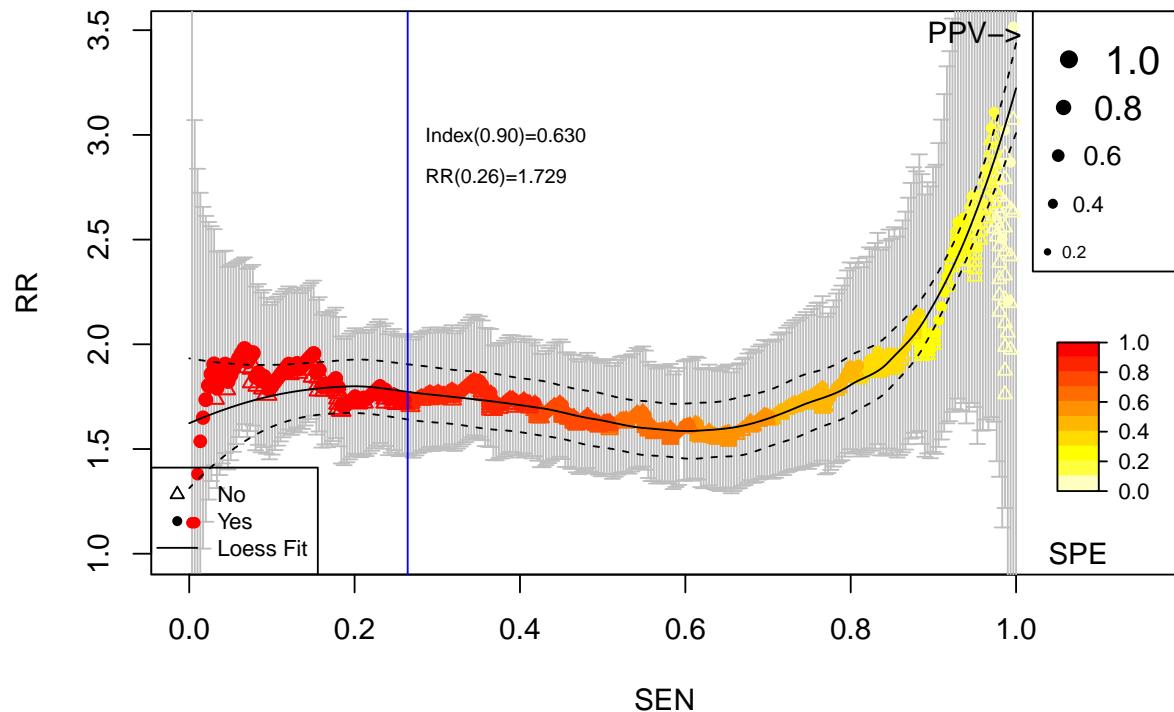
Cumulative vs. Observed: Cal. Test: Breast Cancer



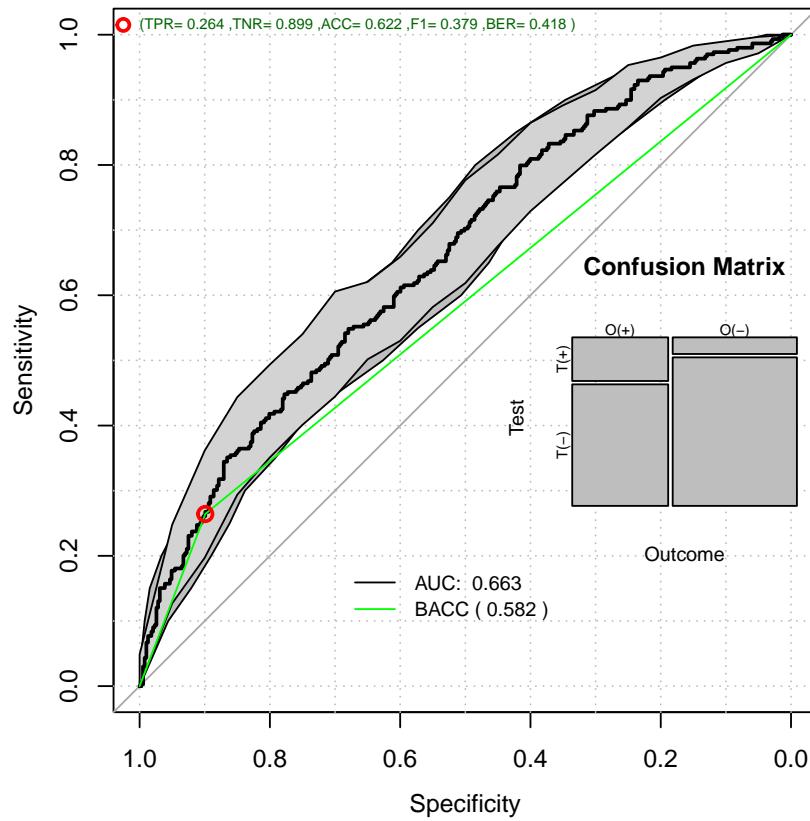
Decision Curve Analysis: Cal. Test: Breast Cancer



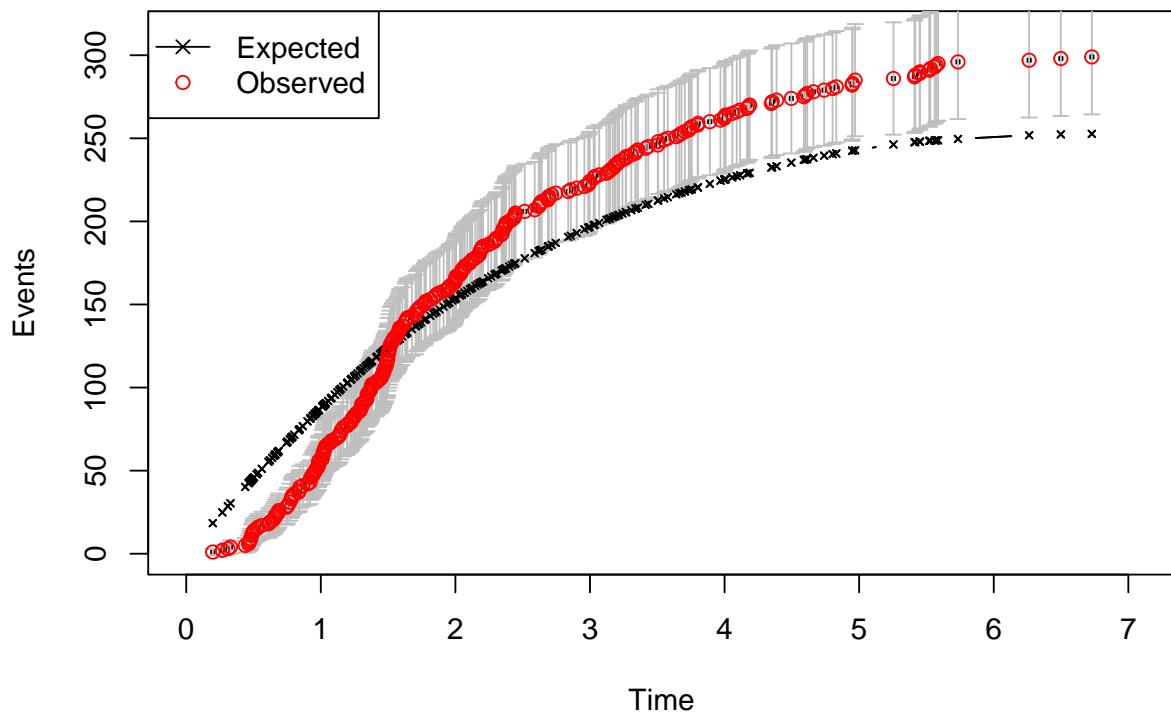
Relative Risk: Cal. Test: Breast Cancer



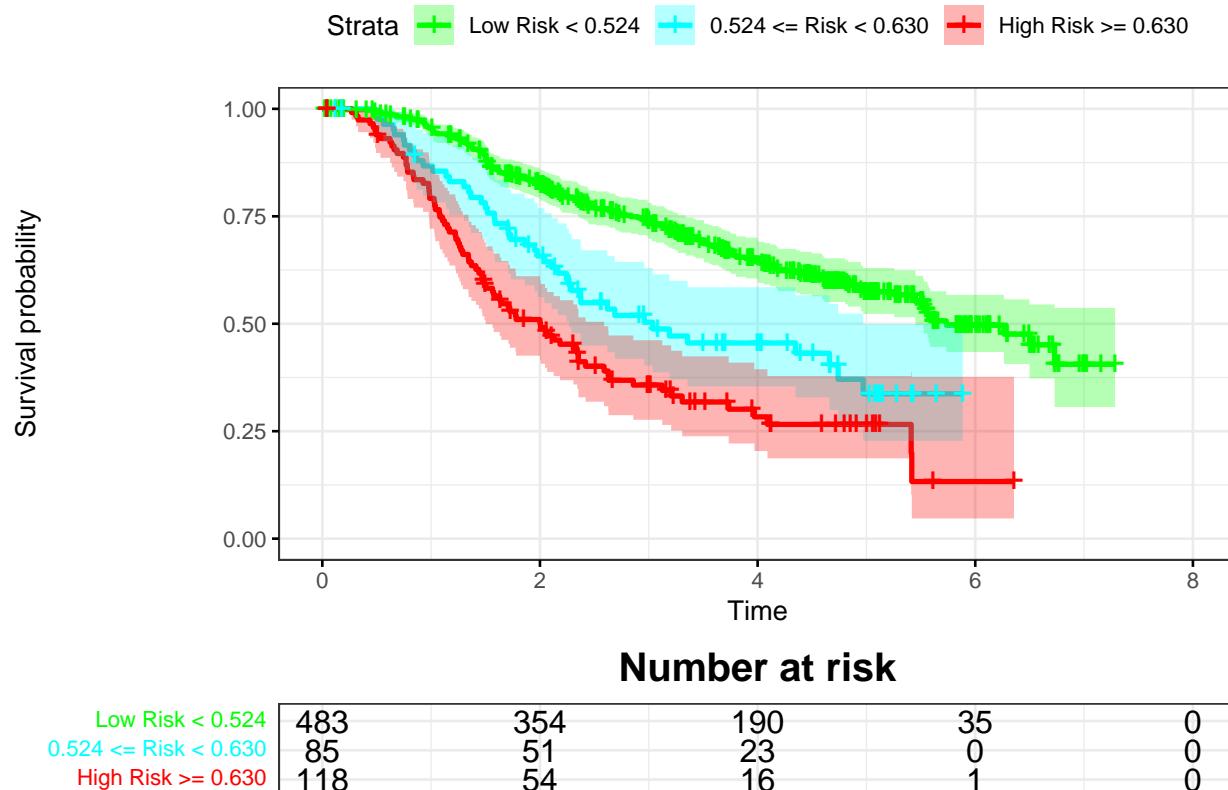
ROC: Cal. Test: Breast Cancer



Time vs. Events: Cal. Test: Breast Cancer



Kaplan–Meier: Cal. Test: Breast Cancer



1.5.3 After Calibration Report

```
pander::pander(t(rrAnalysis$keyPoints), caption="Threshold values")
```

Table 39: Threshold values

	@:0.9	@:0.8	@MAX_BACC	@MAX_RR	@SPE100	p(0.5)
Thr	0.630	0.5243	0.4613	0.304	2.42e-01	0.500
RR	1.741	1.7093	1.6788	3.108	2.20e+01	1.675
RR_LCI	1.479	1.4550	1.4164	1.630	4.75e-02	1.424
RR_UCI	2.048	2.0079	1.9898	5.925	1.02e+04	1.972
SEN	0.268	0.4181	0.5485	0.973	1.00e+00	0.452
SPE	0.899	0.7984	0.6796	0.119	1.29e-02	0.765
BACC	0.583	0.6083	0.6140	0.546	5.06e-01	0.608
NetBenefit	0.020	0.0569	0.0843	0.207	2.58e-01	0.064

```
pander::pander(t(rrAnalysis$OERatio$estimate), caption="O/E Ratio")
```

Table 40: O/E Ratio

O/E	Low	Upper	p.value
1.18	1.05	1.33	0.00461

```
pander::pander(rrAnalysis$c.index, caption="C. Index")
```

- **C Index:** *0.666*
- **Dxy:** *0.331*
- **S.D.:** *0.031*
- **n:** *686*
- **missing:** *0*
- **uncensored:** *299*
- **Relevant Pairs:** *266144*
- **Concordant:** *177175*
- **Uncertain:** *203702*
- **cstatCI:**

mean.C Index	median	lower	upper
0.666	0.665	0.636	0.694

```
pander::pander(t(rrAnalysis$ROCAnalysis$aucs), caption="ROC AUC")
```

Table 42: ROC AUC

est	lower	upper
0.663	0.622	0.703

```
pander::pander((rrAnalysis$ROCAnalysis$sensitivity), caption="Sensitivity")
```

Table 43: Sensitivity

est	lower	upper
0.264	0.215	0.318

```
pander::pander((rrAnalysis$ROCAnalysis$specificity), caption="Specificity")
```

Table 44: Specificity

est	lower	upper
0.899	0.865	0.927

```
pander::pander(t(rrAnalysis$thr_atP), caption="Probability Thresholds")
```

Table 45: Probability Thresholds

	90%	80%
	0.63	0.524

```
pander::pander(rrAnalysis$surdif, caption="Logrank test")
```

Table 46: Logrank test Chisq = 80.478762 on 2 degrees of freedom,
 $p = 0.000000$

	N	Observed	Expected	$(O-E)^2/E$	$(O-E)^2/V$
class=0	483	174	232.7	14.80	67.96
class=1	85	46	32.0	6.16	6.94
class=2	118	79	34.3	58.05	66.45

1.6 Logistic Model

Here we train a logistic model on the same data set

```
## Only label subjects that present event within five years
```

```
dataBrestCancerR <- subset(dataBrestCancerTrain, time>=5 | status==1)
dataBrestCancerR$status <- dataBrestCancerR$status * (dataBrestCancerR$time < 5)
dataBrestCancerR$time <- NULL

#ml <- BSWiMS.model(status~1,data=dataBrestCancerR,loops=20,NumberofRepeats = 5)
mlog <- BSWiMS.model(status~1,data=dataBrestCancerR,loops=1,NumberofRepeats = 5)
```

..

```
sm <- summary(mlog)
pander::pander(sm$coefficients)
```

	Estimate	lower OR	upper	Accuracy	Accuracy	AUC	AUC	AUC	AUC	AUC	NRI	z.IDI	z.NRI	Delta.AUC	Delta.AUC	Frequency
size_nodes	5e-03	1.001	1.001	1.001	0.669	0.571	0.668	0.627	0.500	0.628	0.1123	0.6365	47.86	18.87	0.1284	0.901
nodes	4.33e-02	1.040	1.044	1.048	0.676	0.634	0.690	0.639	0.621	0.662	0.0711	0.5710	64.13	16.17	0.190	0.4941
grade_nbodes	1.02e-02	1.014	1.015	1.016	0.682	0.637	0.686	0.649	0.624	0.655	0.0658	0.5486	63.66	15.65	0.0310	0.871
age_nodels	6e-03	1.001	1.001	1.001	0.678	0.653	0.686	0.642	0.621	0.657	0.0334	0.2131	39.39	5.710	0.0358	0.961
size_grades	5e-03	1.001	1.002	1.002	0.632	0.682	0.686	0.626	0.646	0.655	0.0178	0.2941	6.74	7.728	0.0086	0.481
age_size	8.73e-05	1.000	1.000	1.000	0.608	0.682	0.686	0.577	0.649	0.657	0.0153	0.2915	6.41	7.652	0.0076	0.001
grade	2.27e-01	1.168	1.254	1.347	0.571	0.683	0.690	0.500	0.653	0.662	0.0134	0.1903	6.20	4.983	0.0084	0.611
age_meno	6.04e-03	0.992	0.994	0.996	0.571	0.676	0.686	0.500	0.645	0.657	0.0078	0.0805	4.76	2.337	0.0120	0.651

	Estimate	lower OR	upper OR	Accuracy	Accuracy	AUC	AUC	full.AUC	OI	NRI	z.IDI	z.NRI	Delta.AUC	Frequency		
age_pgr	-5.42e-06	1.000	1.000	0.571	0.686	0.686	0.500	0.656	0.657	0.00510	0.00741	1.11	0.194	0.0004171		
age_grade	1.65e-03	0.997	0.998	0.999	0.574	0.690	0.690	0.507	0.661	0.662	0.00450	0.11372	2.60	2.960	0.0003151	
meno_grade	0.01	1.045	1.107	1.173	0.571	0.683	0.686	0.500	0.652	0.657	0.00420	0.20423	3.47	5.343	0.0044411	
nodes_hormon	1.38e-02	0.979	0.986	0.994	0.587	0.688	0.686	0.526	0.658	0.655	0.00280	0.45523	2.44	12.150	-1	
size	3.94e-03	1.002	1.004	1.006	0.611	0.693	0.690	0.618	0.663	0.662	0.00500	0.21053	3.42	5.600	-1	
meno_pgr	0.00429	1.000	1.000	1.001	0.571	0.687	0.686	0.500	0.657	0.657	0.00310	0.05973	3.35	1.558	-1	
pgr	1.07e-04	-	1.000	1.000	1.000	0.571	0.689	0.686	0.500	0.659	0.655	0.00250	0.19752	2.64	5.745	-1
meno_nodes	0.004123	0.955	0.974	0.994	0.640	0.686	0.686	0.595	0.656	0.657	0.00264	-2.59	-	0.0006311		
grade_pgr	3.51e-05	1.000	1.000	1.000	0.571	0.669	0.668	0.500	0.627	0.628	0.00240	0.17472	2.55	5.058	0.0012521	
meno_size	0.001378	1.000	1.002	1.004	0.604	0.691	0.690	0.578	0.663	0.662	0.00180	0.10222	2.43	2.662	-1	

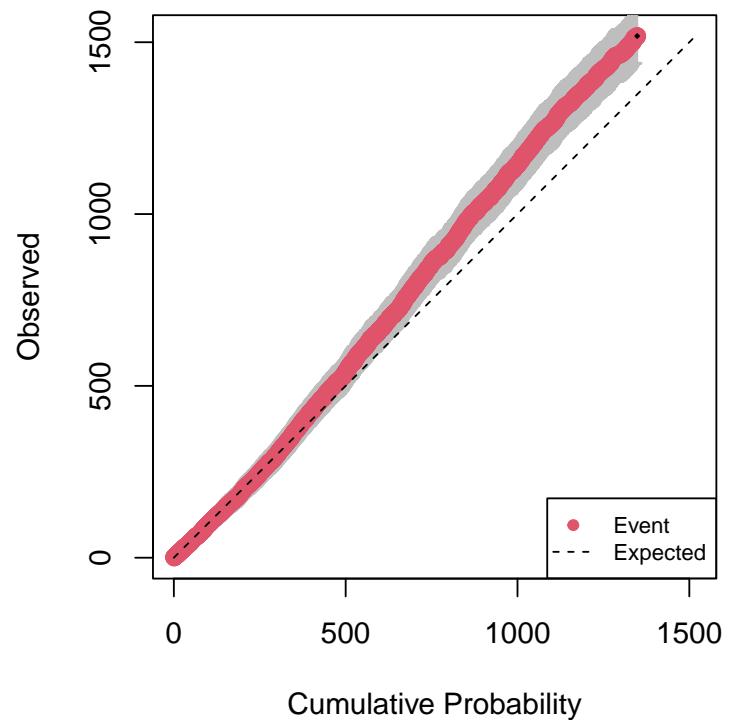
1.7 Logistic Model Performance

```
op <- par(no.readonly = TRUE)

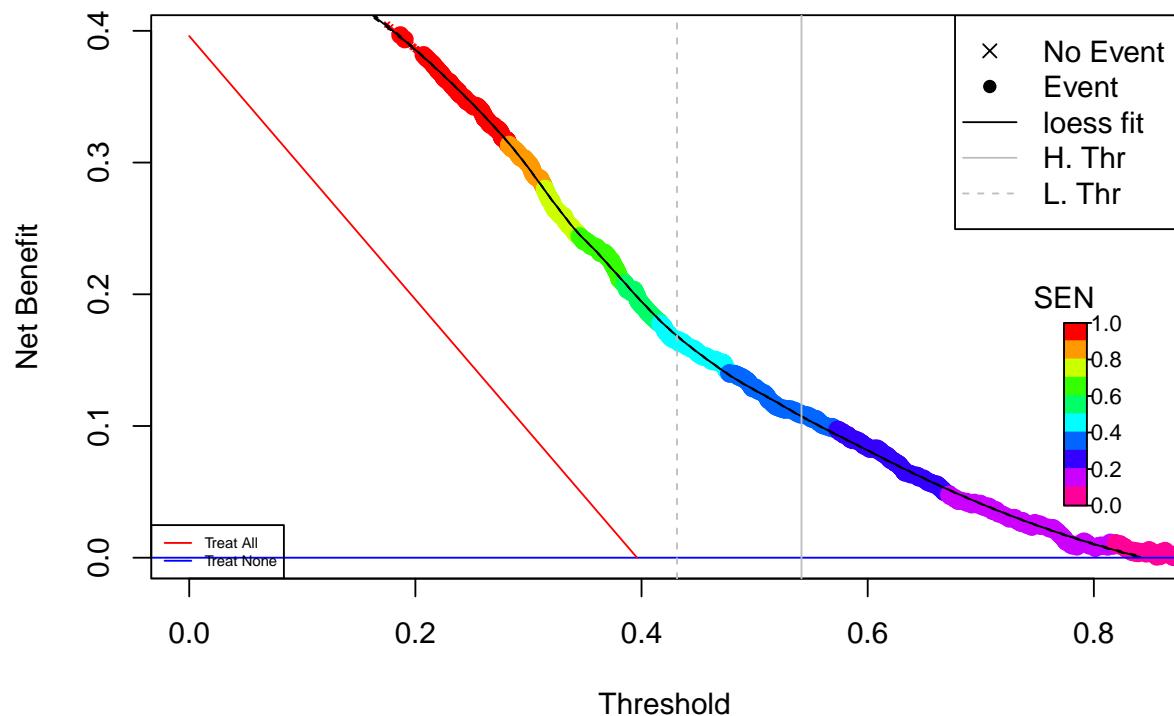
cprob <- predict(mlog,dataBrestCancerTrain)

rdata <- cbind(dataBrestCancerTrain$status,cprob)
rrAnalysisTrain <- RRPlot(rdata,atRate=c(0.90,0.80),
                           timetoEvent=dataBrestCancerTrain$time,
                           title="Logistic Train: Breast Cancer",
                           ysurvlim=c(0.00,1.0),
                           riskTimeInterval=5.0)
```

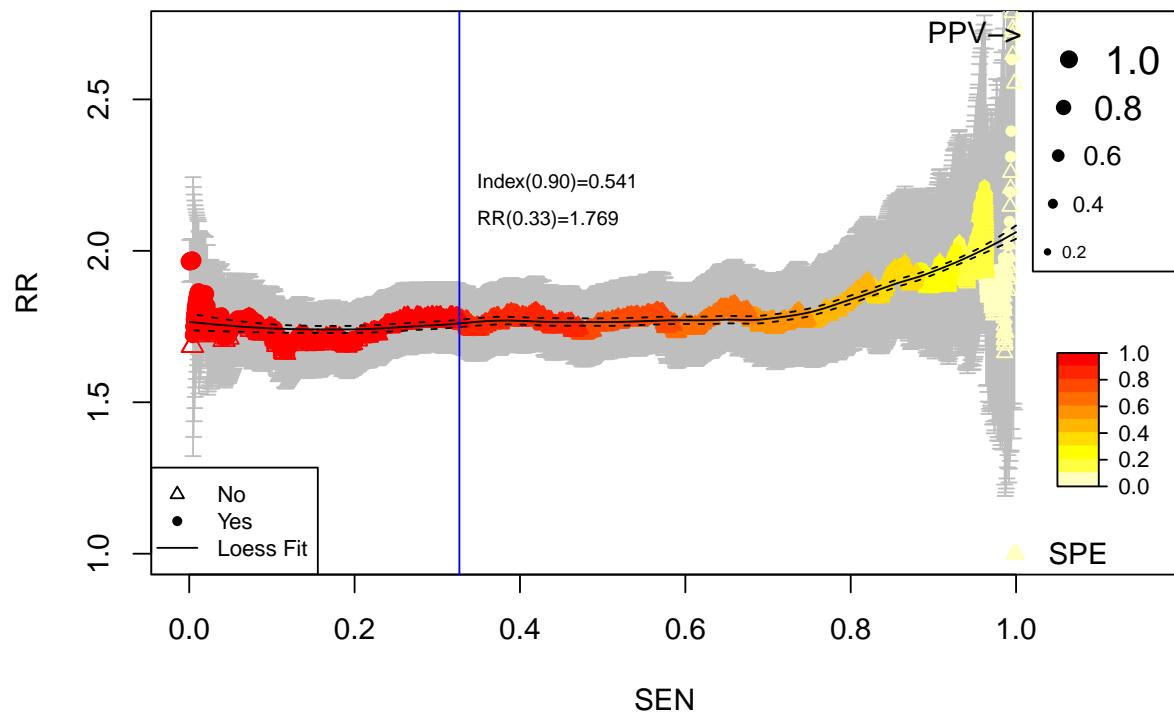
Cumulative vs. Observed: Logistic Train: Breast Cancer



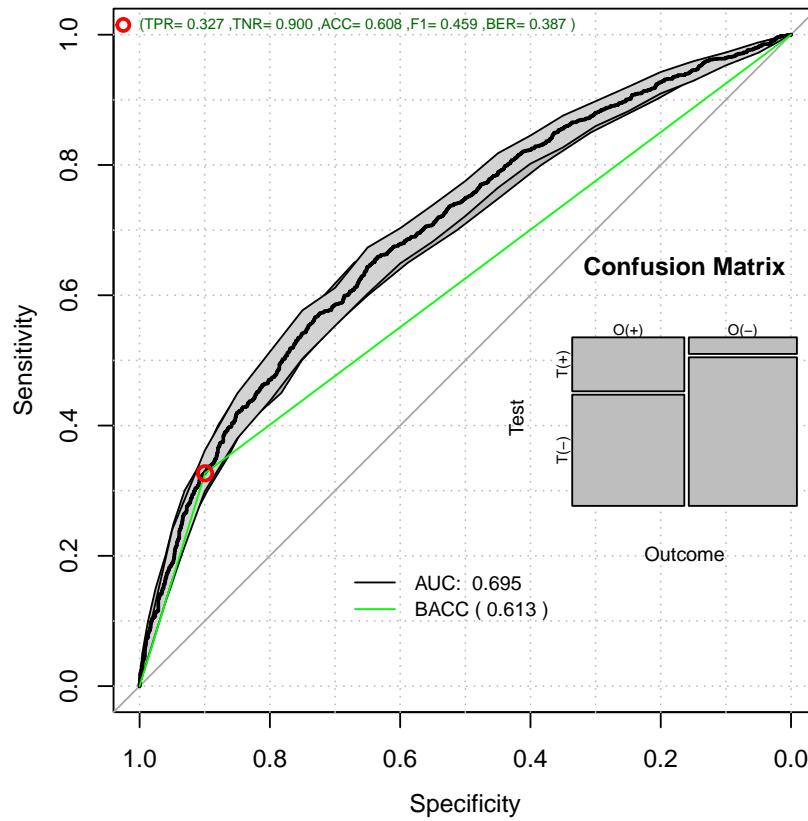
Decision Curve Analysis: Logistic Train: Breast Cancer



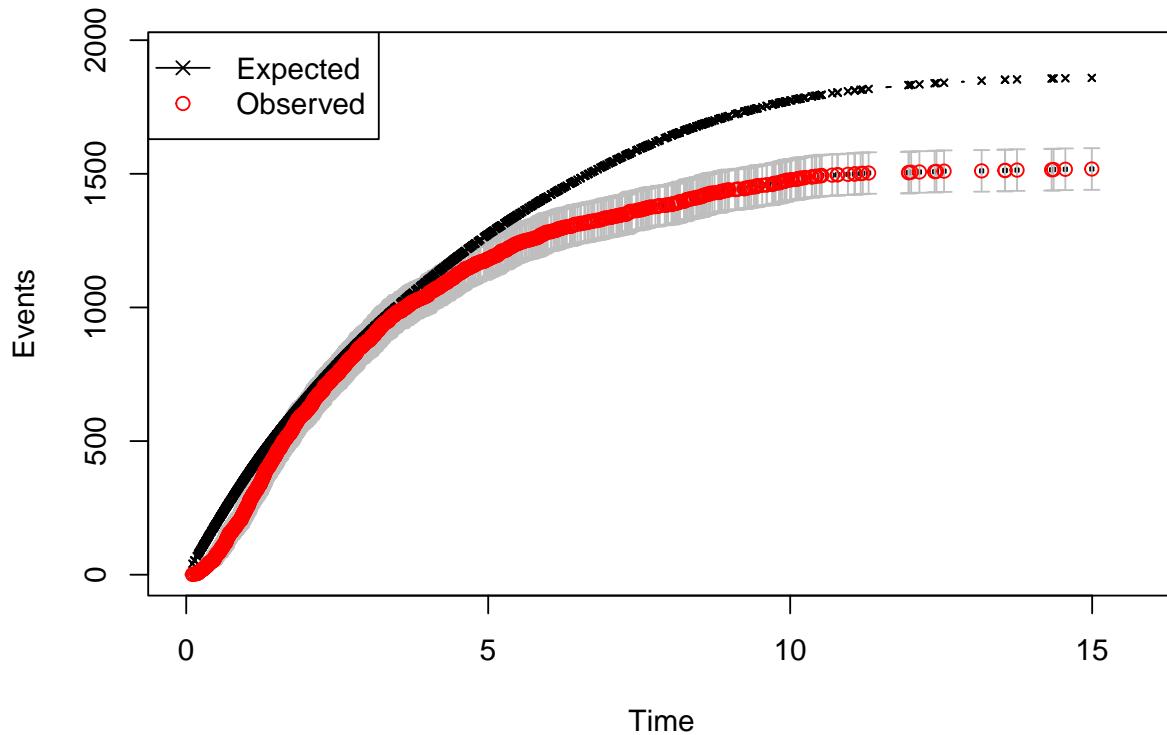
Relative Risk: Logistic Train: Breast Cancer



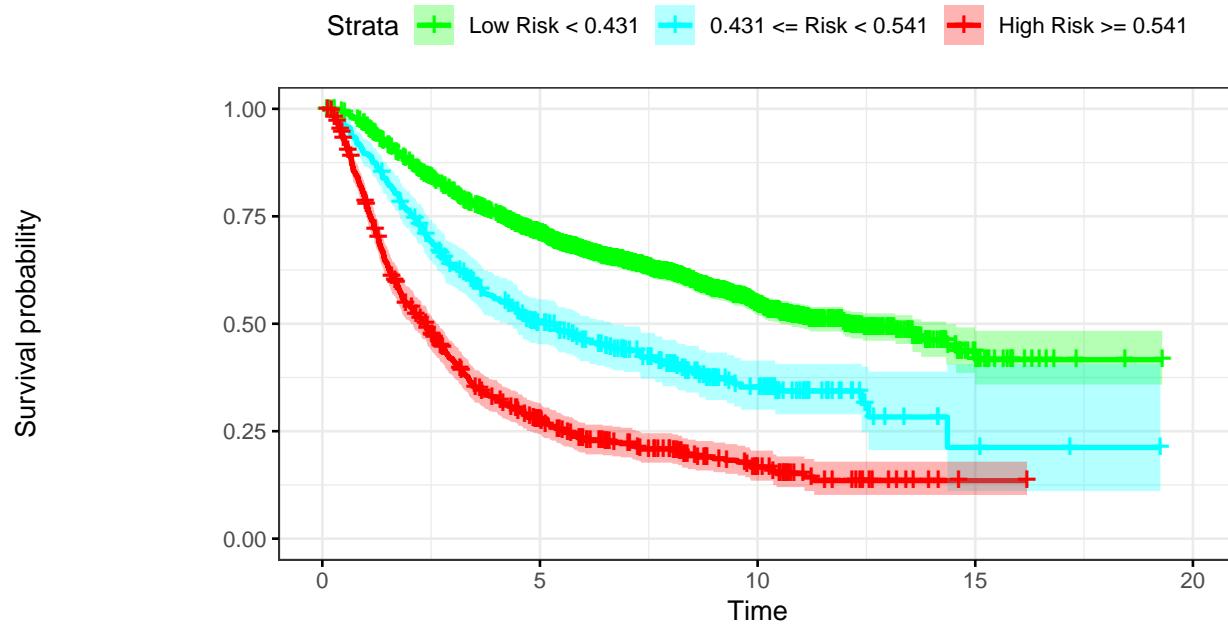
ROC: Logistic Train: Breast Cancer



Time vs. Events: Logistic Train: Breast Cancer



Kaplan–Meier: Logistic Train: Breast Cancer



```
par(op)
```

1.7.1 Training Report

```
pander::pander(t(rrAnalysisTrain$keyPoints), caption="Threshold values")
```

Table 48: Threshold values

	@:0.9	@:0.8	@MAX_BACC	@MAX_RR	@SPE100	p(0.5)
Thr	0.542	0.431	0.394	0.255	0.130969	0.500
RR	1.765	1.739	1.799	2.213	1.000000	1.773
RR_LCI	1.659	1.627	1.676	1.764	0.000000	1.665
RR_UCI	1.879	1.858	1.931	2.777	0.000000	1.888
SEN	0.327	0.470	0.566	0.962	1.000000	0.374
SPE	0.900	0.799	0.731	0.125	0.000683	0.874
BACC	0.613	0.635	0.648	0.543	0.500342	0.624
NetBenefit	0.108	0.165	0.202	0.342	0.435125	0.129

```
pander::pander(t(rrAnalysisTrain$OERatio$estimate), caption="O/E Ratio")
```

Table 49: O/E Ratio

O/E	Low	Upper	p.value
0.817	0.776	0.859	3.78e-16

```
pander::pander(rrAnalysisTrain$c.index, caption="C. Index")
```

- **C Index:** 0.68
- **Dxy:** 0.36
- **S.D.:** 0.014
- **n:** 2982
- **missing:** 0
- **uncensored:** 1518
- **Relevant Pairs:** 6184528
- **Concordant:** 4206600
- **Uncertain:** 2703838
- **cstatCI:**

mean.C Index	median	lower	upper
0.68	0.68	0.666	0.694

```
pander::pander(t(rrAnalysisTrain$ROCAnalysis$aucs), caption="ROC AUC")
```

Table 51: ROC AUC

est	lower	upper
0.695	0.677	0.714

```
pander::pander((rrAnalysisTrain$ROCAnalysis$sensitivity), caption="Sensitivity")
```

Table 52: Sensitivity

est	lower	upper
0.327	0.303	0.351

```
pander::pander((rrAnalysisTrain$ROCAnalysis$specificity), caption="Specificity")
```

Table 53: Specificity

est	lower	upper
0.9	0.883	0.915

```
pander::pander(t(rrAnalysisTrain$thr_atP), caption="Probability Thresholds")
```

Table 54: Probability Thresholds

90%	80%
0.541	0.431

```
pander::pander(rrAnalysisTrain$surdif, caption="Logrank test")
```

Table 55: Logrank test Chisq = 541.976716 on 2 degrees of freedom,
p = 0.000000

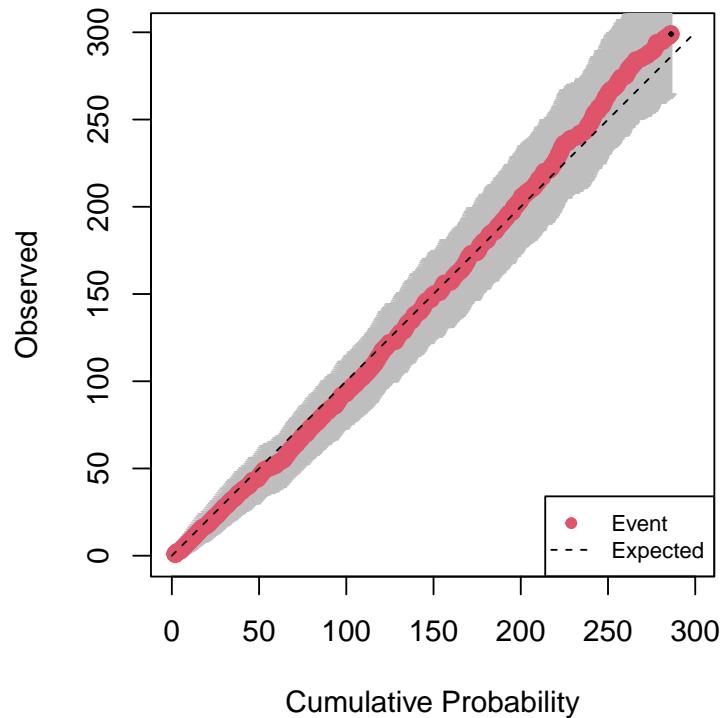
	N	Observed	Expected	(O-E)^2/E	(O-E)^2/V
class=0	1974	804	1144	100.9	415.3
class=1	365	218	170	13.4	15.1
class=2	643	496	204	418.2	490.7

1.7.2 Results on the validation set using Logistic model

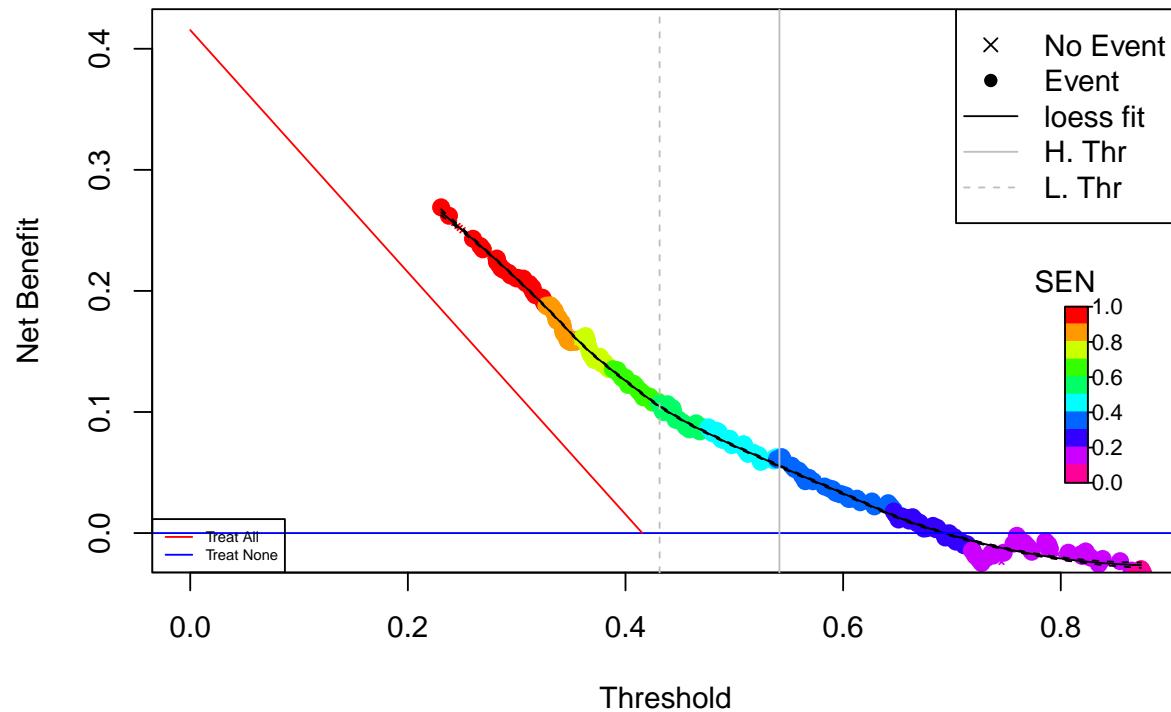
```
pre <- predict(mlog,dataBrestCancerTest)
rdata <- cbind(dataBrestCancerTest$status,pre)

rrAnalysis <- RRPlot(rdata,atThr=rrAnalysisTrain$thr_atP,
                      timetoEvent=dataBrestCancerTest$time,
                      title="Logistic Test: Breast Cancer",
                      ysurvlim=c(0.00,1.0),
                      riskTimeInterval=5)
```

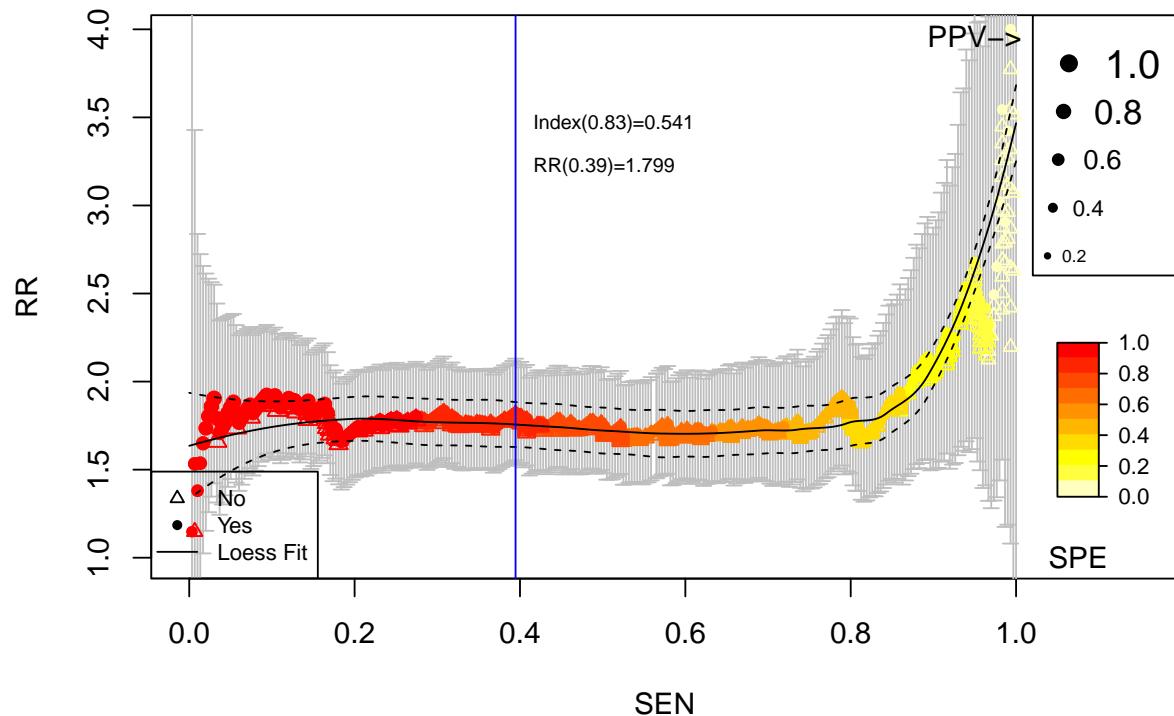
Cumulative vs. Observed: Logistic Test: Breast Cancer



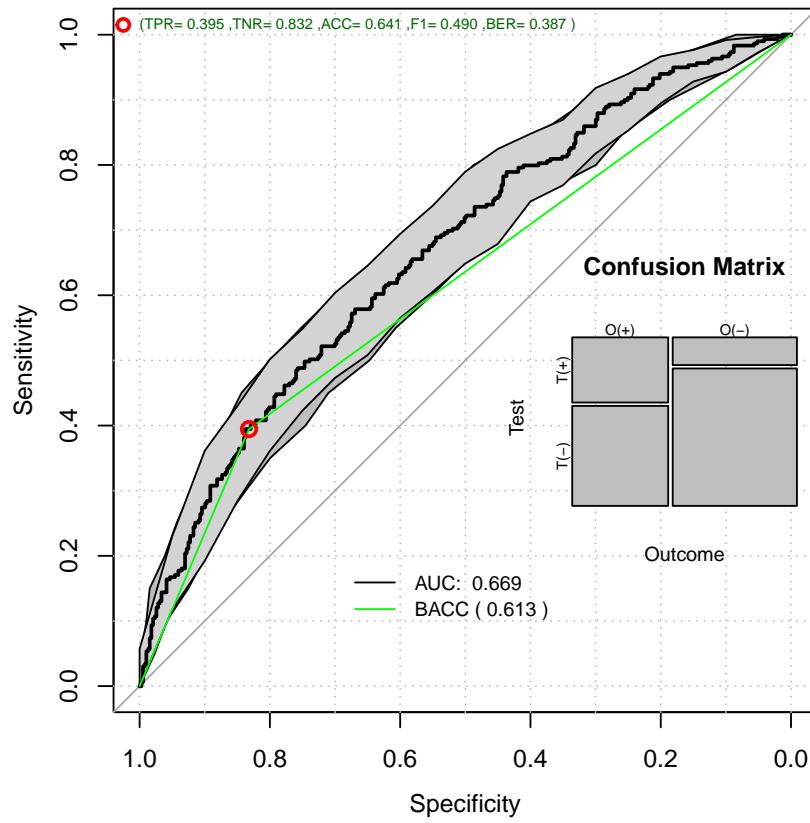
Decision Curve Analysis: Logistic Test: Breast Cancer



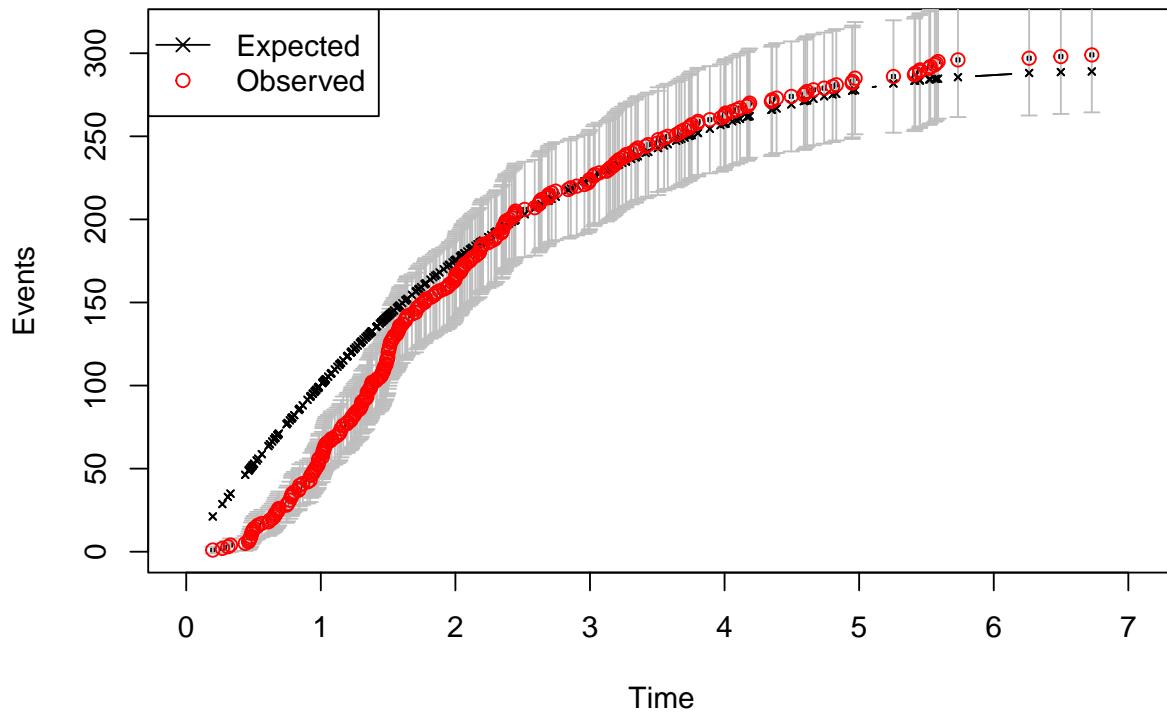
Relative Risk: Logistic Test: Breast Cancer



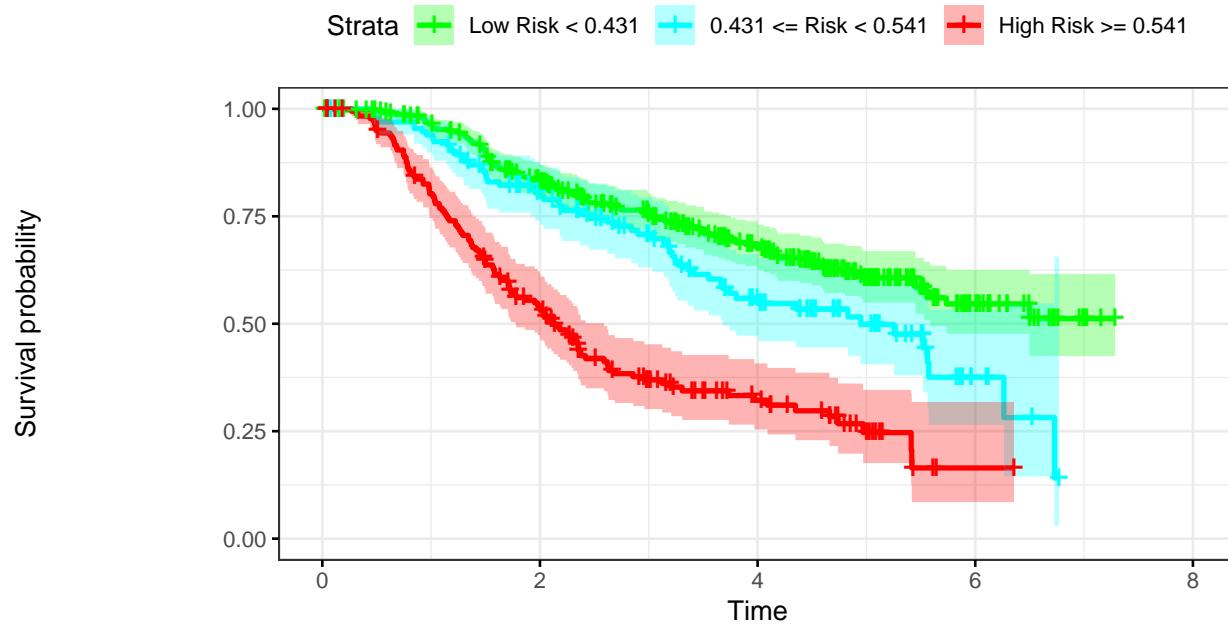
ROC: Logistic Test: Breast Cancer



Time vs. Events: Logistic Test: Breast Cancer



Kaplan–Meier: Logistic Test: Breast Cancer



```
par(op)
```

1.7.3 Validation Report

```
pander::pander(t(rrAnalysis$keyPoints), caption="Threshold values")
```

Table 56: Threshold values

	@:0.541	@:0.431	@MAX_BACC	@MAX_RR	@SPE100	p(0.5)
Thr	0.542	0.431	0.439	0.306	2.31e-01	0.4996
RR	1.792	1.702	1.756	2.678	2.20e+01	1.7318
RR_LCI	1.529	1.428	1.477	1.679	4.75e-02	1.4731
RR_UCI	2.100	2.029	2.088	4.271	1.02e+04	2.0360
SEN	0.395	0.595	0.579	0.950	1.00e+00	0.4482
SPE	0.832	0.638	0.669	0.181	1.29e-02	0.7804
BACC	0.613	0.617	0.624	0.565	5.06e-01	0.6143
NetBenefit	0.060	0.105	0.106	0.210	2.69e-01	0.0717

```
pander::pander(t(rrAnalysis$OERatio$estimate), caption="O/E Ratio")
```

Table 57: O/E Ratio

O/E	Low	Upper	p.value
1.03	0.921	1.16	0.556

```
pander::pander(rrAnalysis$c.index, caption="C. Index")
```

- **C Index:** 0.669
- **Dxy:** 0.338
- **S.D.:** 0.0309
- **n:** 686
- **missing:** 0
- **uncensored:** 299
- **Relevant Pairs:** 266144
- **Concordant:** 178115
- **Uncertain:** 203702
- **cstatCI:**

mean.C Index	median	lower	upper
0.669	0.668	0.638	0.698

```
pander::pander(t(rrAnalysis$ROCAalysis$aucs), caption="ROC AUC")
```

Table 59: ROC AUC

est	lower	upper
0.669	0.628	0.709

```
pander::pander((rrAnalysis$ROCAalysis$sensitivity), caption="Sensitivity")
```

Table 60: Sensitivity

est	lower	upper
0.395	0.339	0.453

```
pander::pander((rrAnalysis$ROCAalysis$specificity), caption="Specificity")
```

Table 61: Specificity

est	lower	upper
0.832	0.791	0.868

```
pander::pander(t(rrAnalysis$thr_atP), caption="Probability Thresholds")
```

Table 62: Probability Thresholds

90%	80%
0.541	0.431

```
pander::pander(rrAnalysis$surdif, caption="Logrank test")
```

Table 63: Logrank test Chisq = 92.507991 on 2 degrees of freedom,
 $p = 0.000000$

	N	Observed	Expected	$(O-E)^2/E$	$(O-E)^2/V$
class=0	369	121	181.7	20.2997	52.3868
class=1	134	60	61.7	0.0479	0.0604
class=2	183	118	55.5	70.2342	88.0195

1.8 Logistic Model Poisson Calibration

```
riskdata <- cbind(dataBrestCancerTrain$status,predict(mlog,dataBrestCancerTrain, type="prob"),dataBrestCancerTrain)
calprob <- CalibrationProbPoissonRisk(riskdata)

pander::pander(c(h0=calprob$h0,
                 Gain=calprob$hazardGain,
                 DeltaTime=calprob$timeInterval),
               caption="Logistic Calibration Parameters")
```

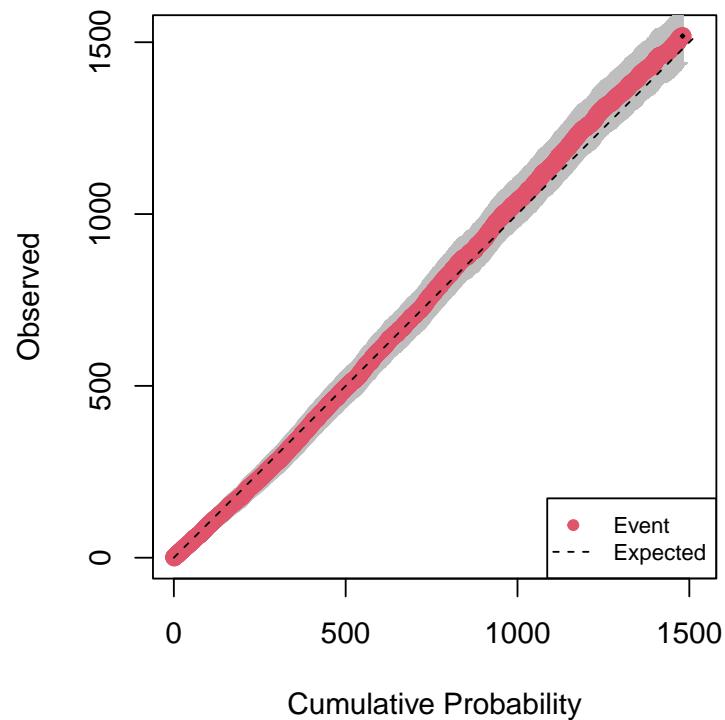
h0	Gain	DeltaTime
0.689	1.33	7.44

```
timeinterval <- calprob$timeInterval;
gain <- calprob$hazardGain

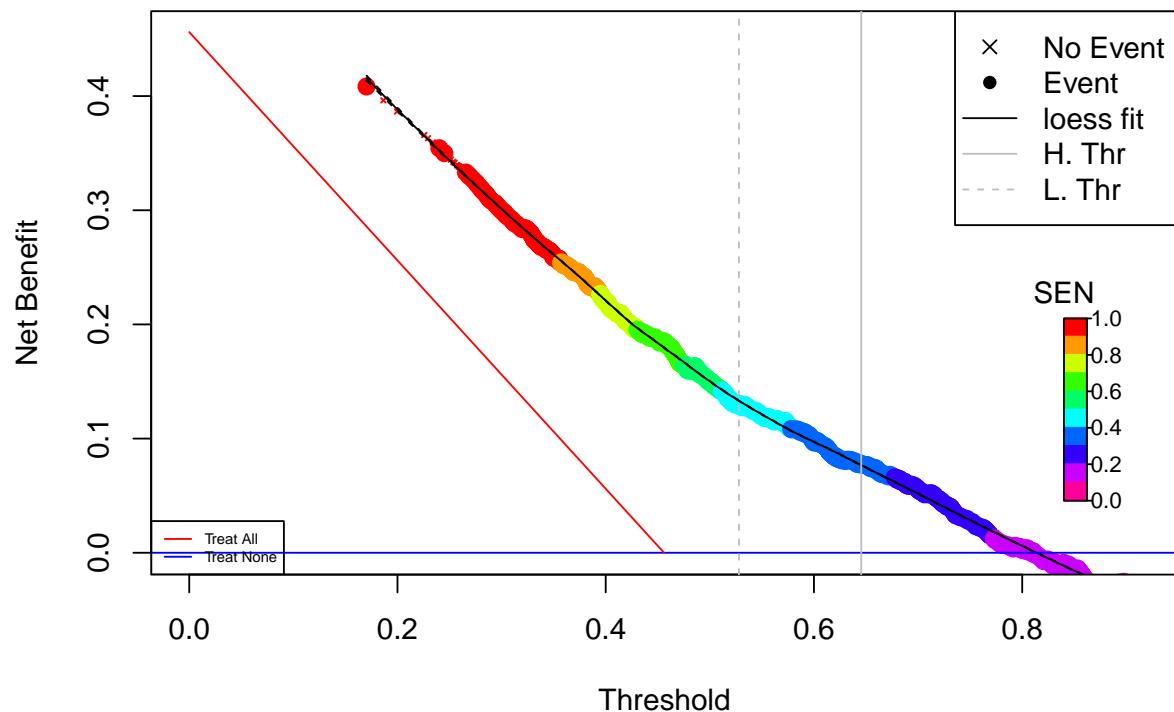
rdata <- cbind(dataBrestCancerTrain$status,calprob$prob)

rrAnalysisTrain <- RRPlot(rdata,atRate=c(0.90,0.80),
                           timetoEvent=dataBrestCancerTrain$time,
                           title="Cal. Logistic Train: Breast Cancer",
                           ysurvlim=c(0.00,1.0),
                           riskTimeInterval=timeinterval)
```

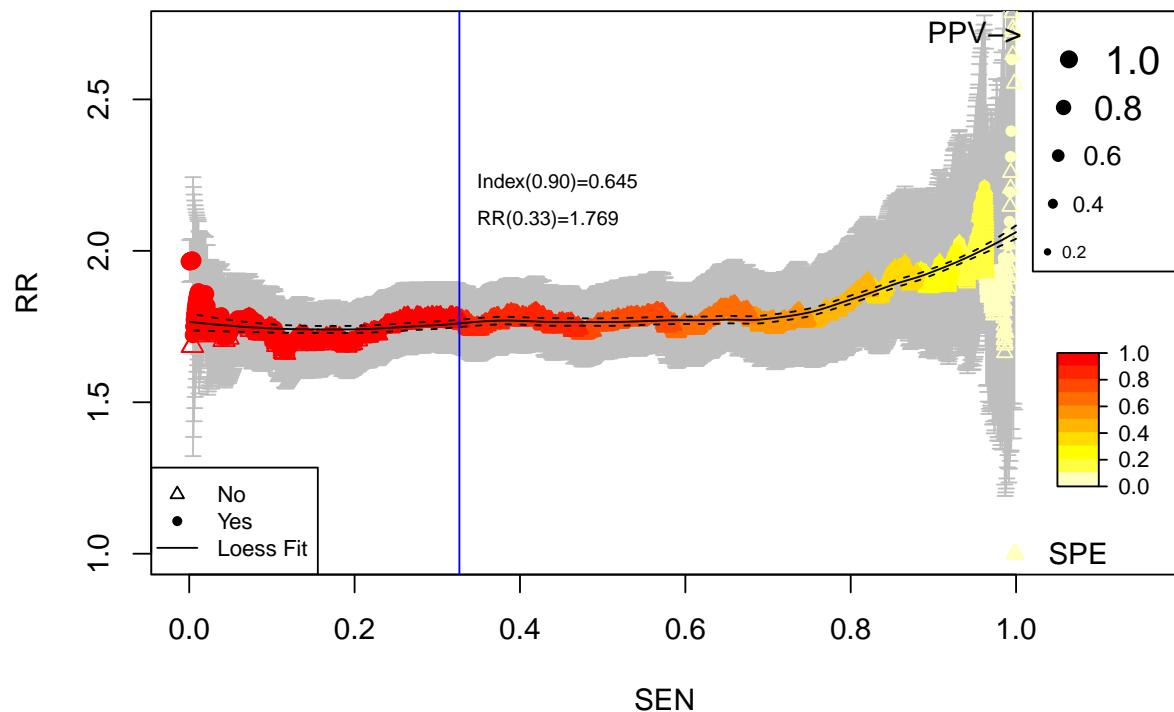
Cumulative vs. Observed: Cal. Logistic Train: Breast Cancer



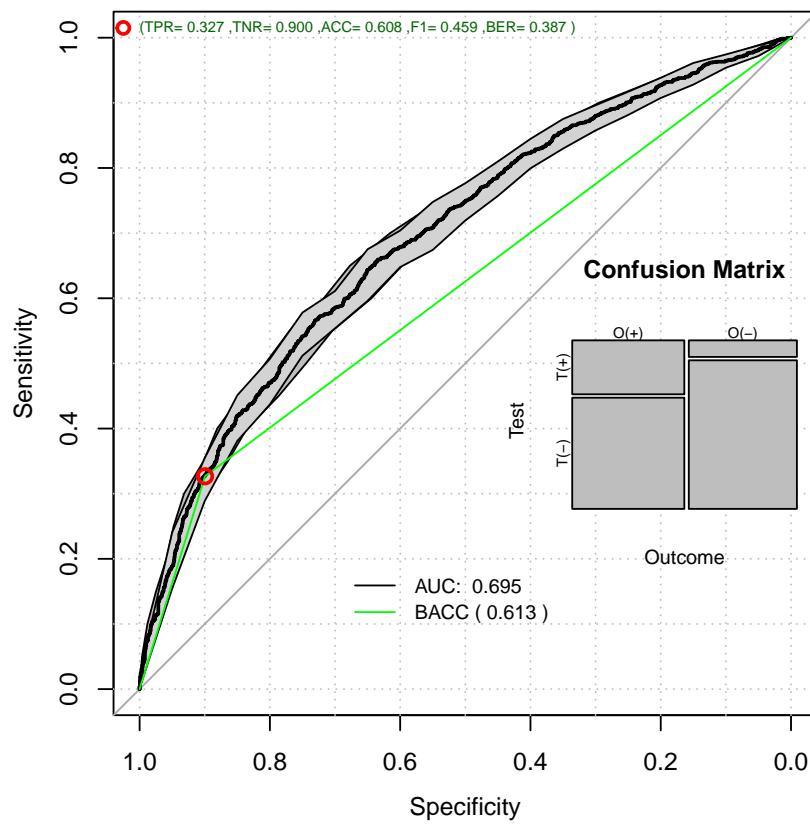
Decision Curve Analysis: Cal. Logistic Train: Breast Cancer



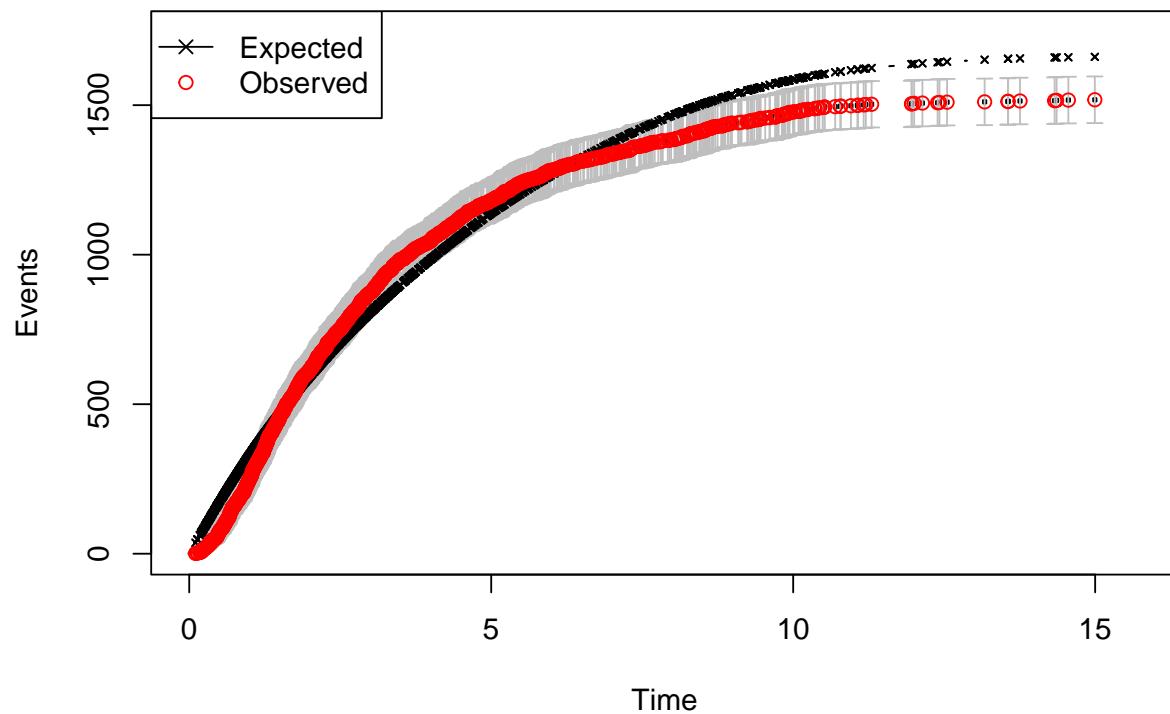
Relative Risk: Cal. Logistic Train: Breast Cancer



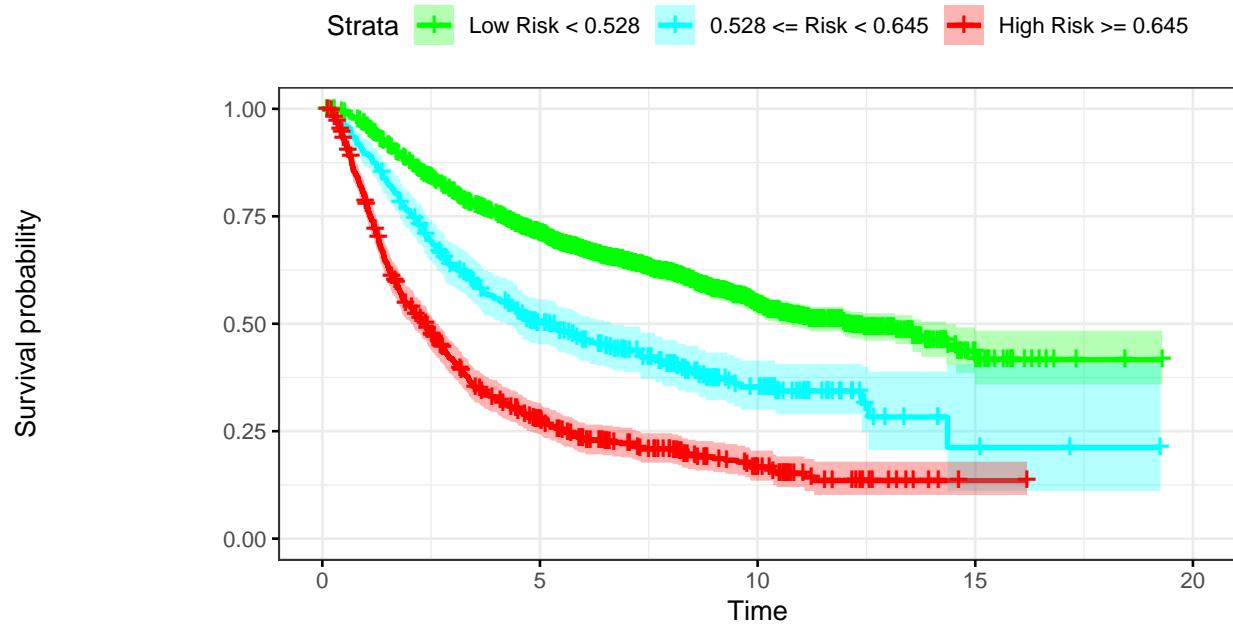
ROC: Cal. Logistic Train: Breast Cancer



Time vs. Events: Cal. Logistic Train: Breast Cancer



Kaplan–Meier: Cal. Logistic Train: Breast Cancer



```
par(op)
```

1.8.1 Report of the calibrated logistic: training

```
pander::pander(t(rrAnalysisTrain$keyPoints), caption="Threshold values")
```

Table 65: Threshold values

	@:0.9	@:0.8	@MAX_BACC	@MAX_RR	@SPE100	p(0.5)
Thr	0.6463	0.528	0.486	0.324	0.170289	0.500
RR	1.7654	1.739	1.799	2.213	1.000000	1.764
RR_LCI	1.6587	1.627	1.676	1.764	0.000000	1.648
RR_UCI	1.8790	1.858	1.931	2.777	0.000000	1.889
SEN	0.3267	0.470	0.566	0.962	1.000000	0.519
SPE	0.8996	0.799	0.731	0.125	0.000683	0.765
BACC	0.6132	0.635	0.648	0.543	0.500342	0.642
NetBenefit	0.0763	0.129	0.163	0.284	0.408374	0.149

```
pander::pander(t(rrAnalysisTrain$OERatio$estimate), caption="O/E Ratio")
```

Table 66: O/E Ratio

O/E	Low	Upper	p.value
0.914	0.868	0.961	0.000392

```
pander::pander(rrAnalysisTrain$c.index, caption="C. Index")
```

- **C Index:** 0.68
- **Dxy:** 0.36
- **S.D.:** 0.014
- **n:** 2982
- **missing:** 0
- **uncensored:** 1518
- **Relevant Pairs:** 6184528
- **Concordant:** 4206583
- **Uncertain:** 2703838
- **cstatCI:**

mean.C Index	median	lower	upper
0.68	0.68	0.667	0.693

```
pander::pander(t(rrAnalysisTrain$ROCAnalysis$aucs), caption="ROC AUC")
```

Table 68: ROC AUC

est	lower	upper
0.695	0.677	0.714

```
pander::pander((rrAnalysisTrain$ROCAnalysis$sensitivity), caption="Sensitivity")
```

Table 69: Sensitivity

est	lower	upper
0.327	0.303	0.351

```
pander::pander((rrAnalysisTrain$ROCAnalysis$specificity), caption="Specificity")
```

Table 70: Specificity

est	lower	upper
0.9	0.883	0.915

```
pander::pander(t(rrAnalysisTrain$thr_atP), caption="Probability Thresholds")
```

Table 71: Probability Thresholds

90%	80%
0.645	0.528

```
pander::pander(rrAnalysisTrain$surdif, caption="Logrank test")
```

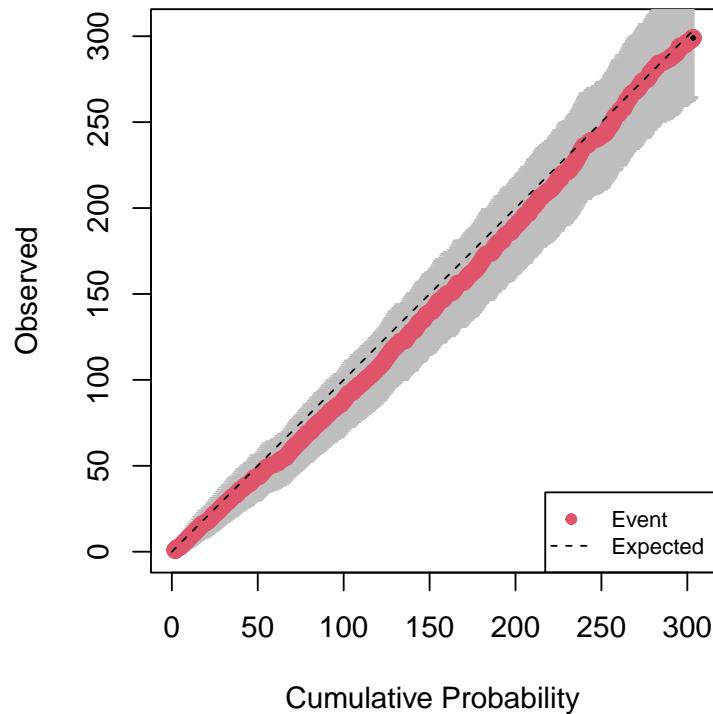
Table 72: Logrank test Chisq = 541.976716 on 2 degrees of freedom,
p = 0.000000

	N	Observed	Expected	(O-E)^2/E	(O-E)^2/V
class=0	1974	804	1144	100.9	415.3
class=1	365	218	170	13.4	15.1
class=2	643	496	204	418.2	490.7

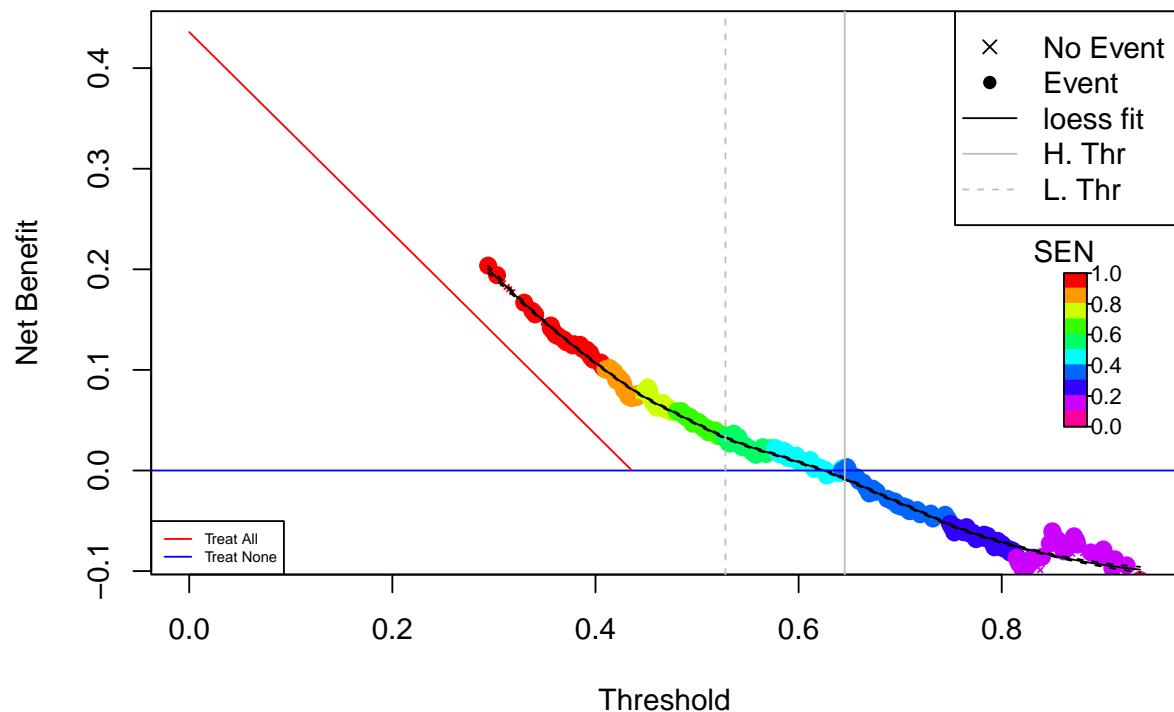
```
probLog <- predict(mlog,dataBrestCancerTest)
aprob <- adjustProb(probLog,gain)

rdata <- cbind(dataBrestCancerTest$status,aprob)
rrAnalysisTestLogistic <- RRPlot(rdata,atThr=rrAnalysisTrain$thr_atP,
                                   timetoEvent=dataBrestCancerTest$time,
                                   title="Cal. Logistic Test: Breast Cancer",
                                   ysurvlim=c(0.00,1.0),
                                   riskTimeInterval=timeinterval)
```

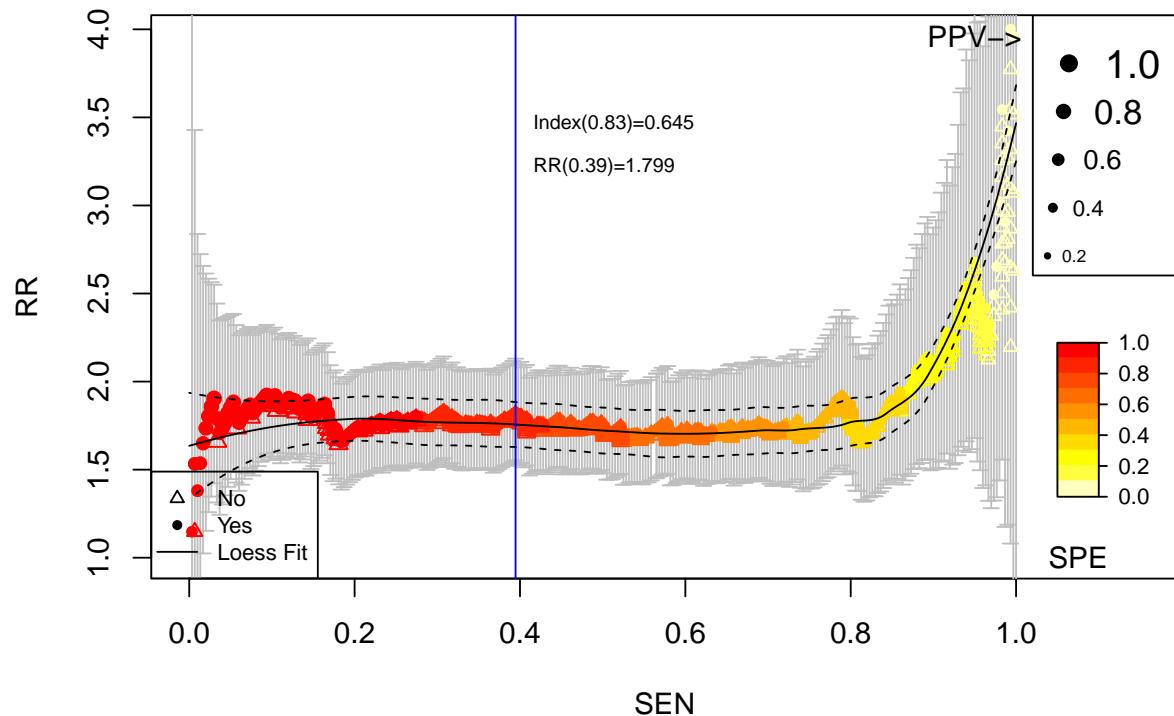
Cumulative vs. Observed: Cal. Logistic Test: Breast Cancer



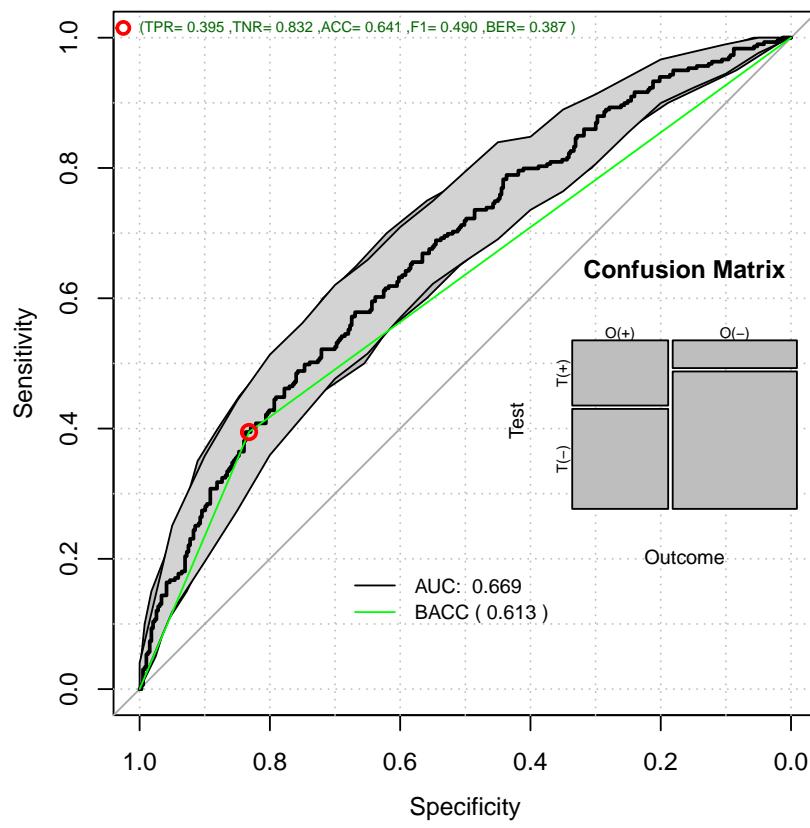
Decision Curve Analysis: Cal. Logistic Test: Breast Cancer



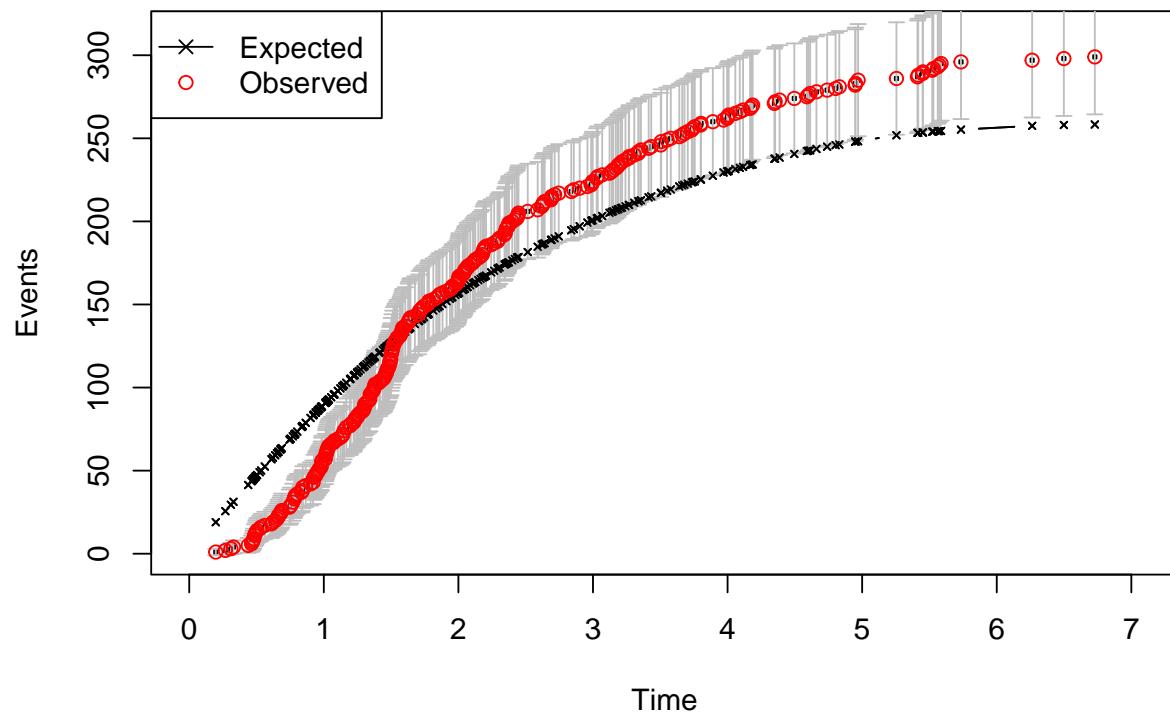
Relative Risk: Cal. Logistic Test: Breast Cancer



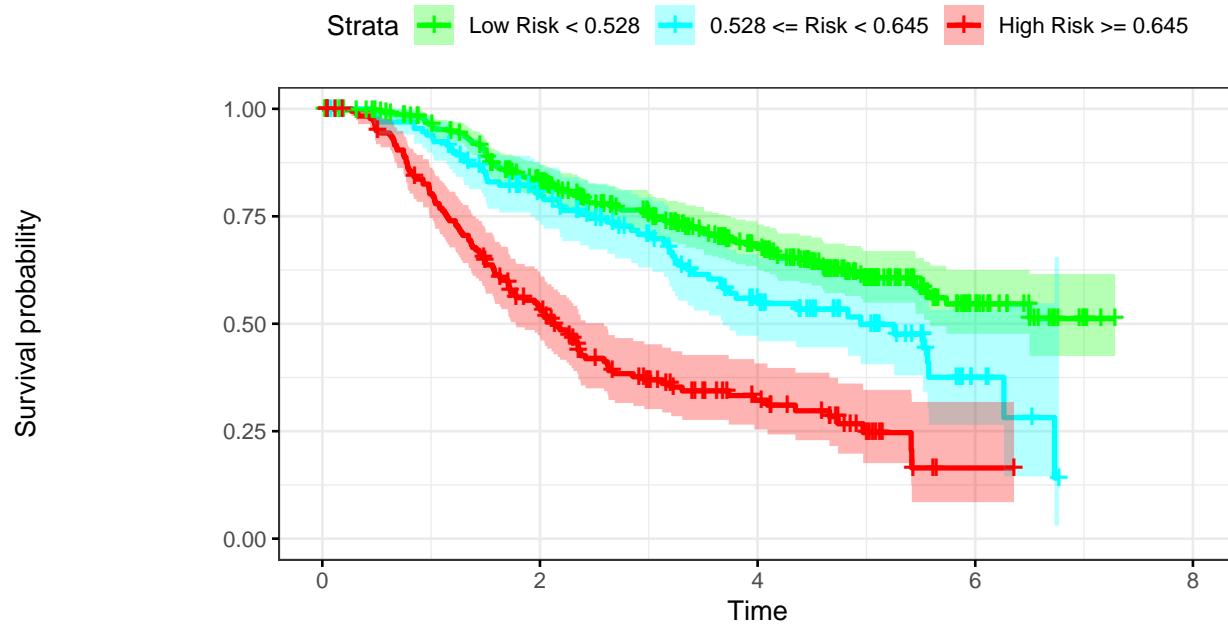
ROC: Cal. Logistic Test: Breast Cancer



Time vs. Events: Cal. Logistic Test: Breast Cancer



Kaplan–Meier: Cal. Logistic Test: Breast Cancer



```
par(op)
```

1.8.2 Report of the calibrated validation

```
pander::pander(t(rrAnalysisTestLogistic$keyPoints), caption="Threshold values")
```

Table 73: Threshold values

	@:0.645	@:0.528	@MAX_BACC	@MAX_RR	@SPE100	p(0.5)
Thr	0.645672	0.5277	0.5360	0.385	2.94e-01	0.5001
RR	1.791927	1.7024	1.7562	2.678	2.20e+01	1.7232
RR_LCI	1.529135	1.4283	1.4771	1.679	4.75e-02	1.4313
RR_UCI	2.099881	2.0290	2.0880	4.271	1.02e+04	2.0746
SEN	0.394649	0.5953	0.5786	0.950	1.00e+00	0.6555
SPE	0.832041	0.6382	0.6693	0.181	1.29e-02	0.5762
BACC	0.613345	0.6168	0.6239	0.565	5.06e-01	0.6159
NetBenefit	-0.000601	0.0315	0.0367	0.125	2.04e-01	0.0466

```
pander::pander(t(rrAnalysisTestLogistic$OERatio$estimate), caption="O/E Ratio")
```

Table 74: O/E Ratio

O/E	Low	Upper	p.value
1.16	1.03	1.3	0.0128

```
pander::pander(rrAnalysisTestLogistic$c.index, caption="C. Index")
```

- **C Index:** 0.669
- **Dxy:** 0.338
- **S.D.:** 0.0309
- **n:** 686
- **missing:** 0
- **uncensored:** 299
- **Relevant Pairs:** 266144
- **Concordant:** 178115
- **Uncertain:** 203702
- **cstatCI:**

mean.C Index	median	lower	upper
0.669	0.669	0.636	0.698

```
pander::pander(t(rrAnalysisTestLogistic$ROCAccuracy$aucs), caption="ROC AUC")
```

Table 76: ROC AUC

est	lower	upper
0.669	0.628	0.709

```
pander::pander((rrAnalysisTestLogistic$ROCAccuracy$sensitivity), caption="Sensitivity")
```

Table 77: Sensitivity

est	lower	upper
0.395	0.339	0.453

```
pander::pander((rrAnalysisTestLogistic$ROCAccuracy$specificity), caption="Specificity")
```

Table 78: Specificity

est	lower	upper
0.832	0.791	0.868

```
pander::pander(t(rrAnalysisTestLogistic$thr_atP), caption="Probability Thresholds")
```

Table 79: Probability Thresholds

	90%	80%
	0.645	0.528

```
pander::pander(rrAnalysisTestLogistic$surdif, caption="Logrank test")
```

Table 80: Logrank test Chisq = 92.507991 on 2 degrees of freedom,
 $p = 0.000000$

	N	Observed	Expected	$(O-E)^2/E$	$(O-E)^2/V$
class=0	369	121	181.7	20.2997	52.3868
class=1	134	60	61.7	0.0479	0.0604
class=2	183	118	55.5	70.2342	88.0195

1.9 Comparing the COX and Logistic Models on the Independent Data

```
pander::pander(t(rrCoxTestAnalysis$0Acum95ci))
```

mean	50%	2.5%	97.5%
1	1	1	1.01

```
pander::pander(t(rrAnalysisTestLogistic$0Acum95ci))
```

mean	50%	2.5%	97.5%
0.944	0.943	0.94	0.947

```
pander::pander(t(rrCoxTestAnalysis$0E95ci))
```

mean	50%	2.5%	97.5%
1.06	1.06	1.03	1.08

```
pander::pander(t(rrAnalysisTestLogistic$0E95ci))
```

mean	50%	2.5%	97.5%
0.981	0.982	0.956	1.01

```
maxobs <- sum(dataBrestCancerTest$status)

par(mfrow=c(1,2), cex=0.75)

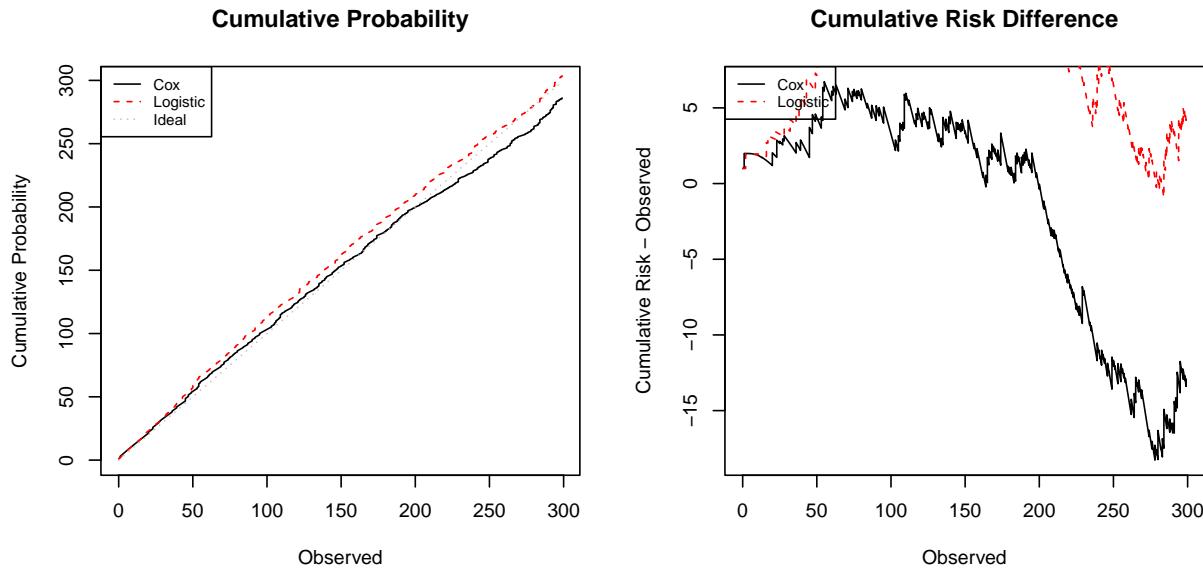
plot(rrCoxTestAnalysis$CumulativeOvs[,1:2], type="l", lty=1,
```

```

    main="Cumulative Probability",
    xlab="Observed",
    ylab="Cumulative Probability",
    ylim=c(0,maxobs),
    xlim=c(0,maxobs))
lines(rrAnalysisTestLogistic$CumulativeOvs[,1:2],lty=2,col="red")
lines(x=c(0,maxobs),y=c(0,maxobs),lty=3,col="gray")
legend("topleft",legend = c("Cox","Logistic","Ideal"),
      col=c("black","red","gray"),
      lty=c(1,2,3),
      cex=0.75
)
)

plot(rrCoxTestAnalysis$CumulativeOvs$Observed,
      rrCoxTestAnalysis$CumulativeOvs$Cumulative-
      rrCoxTestAnalysis$CumulativeOvs$Observed,
      main="Cumulative Risk Difference",
      xlab="Observed",
      ylab="Cumulative Risk - Observed",
      type="l",
      lty=1)
lines(rrAnalysisTestLogistic$CumulativeOvs$Observed,
      rrAnalysisTestLogistic$CumulativeOvs$Cumulative-
      rrAnalysisTestLogistic$CumulativeOvs$Observed,
      lty=2,
      col="red")
legend("topleft",legend = c("Cox","Logistic"),
      col=c("black","red"),
      lty=c(1,2),
      cex=0.75
)
)

```



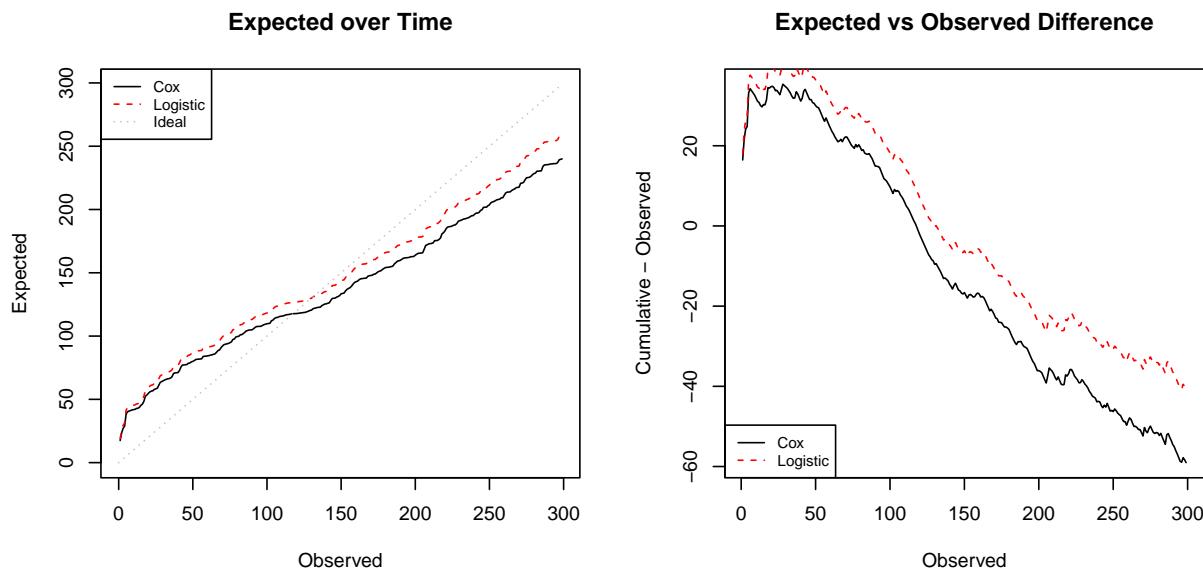
```

plot(rrCoxTestAnalysis$OEData[,2:3], type="l", lty=1,
      main="Expected over Time",
      xlab="Observed",
      ylab="Expected",
      ylim=c(0,maxobs),
      xlim=c(0,maxobs))
lines(rrAnalysisTestLogistic$OEData[,2:3], lty=2, col="red")
lines(x=c(0,maxobs),y=c(0,maxobs), lty=3, col="gray")
legend("topleft", legend = c("Cox", "Logistic", "Ideal"),
       col=c("black", "red", "gray"),
       lty=c(1,2,3),
       cex=0.75
)

plot(rrCoxTestAnalysis$OEData$Observed,
      rrCoxTestAnalysis$OEData$Expected-
          rrCoxTestAnalysis$OEData$Observed,
      main="Expected vs Observed Difference",
      xlab="Observed",
      ylab="Cumulative - Observed",
      type="l",
      lty=1)
lines(rrAnalysisTestLogistic$OEData$Observed,
      rrAnalysisTestLogistic$OEData$Expected-
          rrAnalysisTestLogistic$OEData$Observed,
      lty=2, col="red")

legend("bottomleft", legend = c("Cox", "Logistic"),
       col=c("black", "red"),
       lty=c(1,2),
       cex=0.75
)

```



```
par(op)
```