# Risk-Evaluation: Breast Cancer Royston-Altman

Jose Tamez

2023-04-25

## 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:

### 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
```

```
source("~/GitHub/FRESA.CAD/R/RRPlot.R")
source("~/GitHub/FRESA.CAD/R/PoissonEventRiskCalibration.R")
op <- par(no.readonly = TRUE)
pander::panderOptions('digits', 3)
pander::panderOptions('table.split.table', 400)
pander::panderOptions('keep.trailing.zeros',TRUE)
```

## Breast Cancer Royston-Altman data

**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 |

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

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

data$`(Intercept)` <- NULL

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

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

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

Table 2: gbsg

| 0 | 1 |
|---|---|
| 499 | 183 |

## Cox Modeling

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

——.

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

| | Estimate | lower HR | upperu. | Accuracy | Accuracy | full.Accuracy | AUC | AUC | full.AUC | IDI | NRI | z.IDI | z.NRI | Delta.AUC | Frequency |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **age__nodes** | 0.000716 | 1.001 | 1.001 | 1.001 | 0.626 | 0.600 | 0.632 | 0.630 | 0.601 | 0.634 | 0.03040 | 0.4594 | 12.81 | 14.37 | 0.0330561 |
| **size__grade** | 0.005649 | 1.005 | 1.006 | 1.006 | 0.598 | 0.623 | 0.632 | 0.599 | 0.626 | 0.634 | 0.01868 | 0.3914 | 9.82 | 11.29 | 0.0079471 |
| **nodes** | 0.086582 | 1.082 | 1.090 | 1.099 | 0.637 | 0.642 | 0.643 | 0.640 | 0.643 | 0.644 | 0.00745 | 0.0564 | 8.33 | 1.66 | 0.0001481 |
| **size** | 0.006888 | 1.005 | 1.007 | 1.009 | 0.595 | 0.641 | 0.643 | 0.595 | 0.642 | 0.644 | 0.01447 | 0.3587 | 8.05 | 9.97 | 0.0013221 |
| **size__nodes** | 1.000 | 1.000 | 1.000 | 1.000 | 0.624 | 0.643 | 0.643 | 0.629 | 0.644 | 0.644 | 0.00340 | 0.3430 | 7.25 | 9.57 | -1 |
| | 0.000378 | | | | | | | | | | | | | | 0.000377 |
| **age__size** | -0.000149 | 1.000 | 1.000 | 1.000 | 0.567 | 0.627 | 0.632 | 0.568 | 0.630 | 0.634 | 0.00635 | 0.1935 | 5.95 | 5.36 | 0.0040781 |
| **grade** | 0.204934 | 1.146 | 1.227 | 1.314 | 0.565 | 0.637 | 0.643 | 0.561 | 0.638 | 0.644 | 0.00926 | 0.2069 | 5.88 | 6.31 | 0.0053441 |
| **age** | -0.003113 | 0.996 | 0.997 | 0.998 | 0.513 | 0.628 | 0.643 | 0.513 | 0.628 | 0.644 | 0.00410 | 0.0917 | 5.27 | 2.51 | 0.0154651 |
| **grade__nodes** | 0.981 | 0.986 | 0.992 | 0.635 | 0.645 | 0.643 | 0.639 | 0.646 | 0.644 | 0.00207 | -0.0910 | 5.03 | -2.55 | -1 | 0.002609 |
| | 0.013784 | | | | | | | | | | | | | | |

## Cox Model Performance

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

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

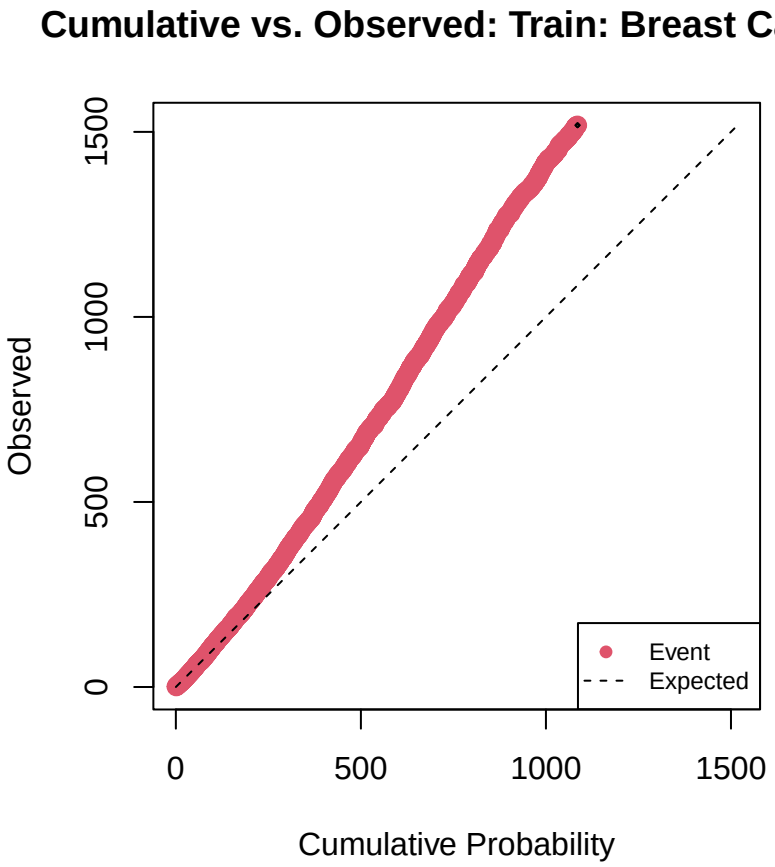
Here we will use the predicted event probability assuming a baseline hazard for events withing 5 years

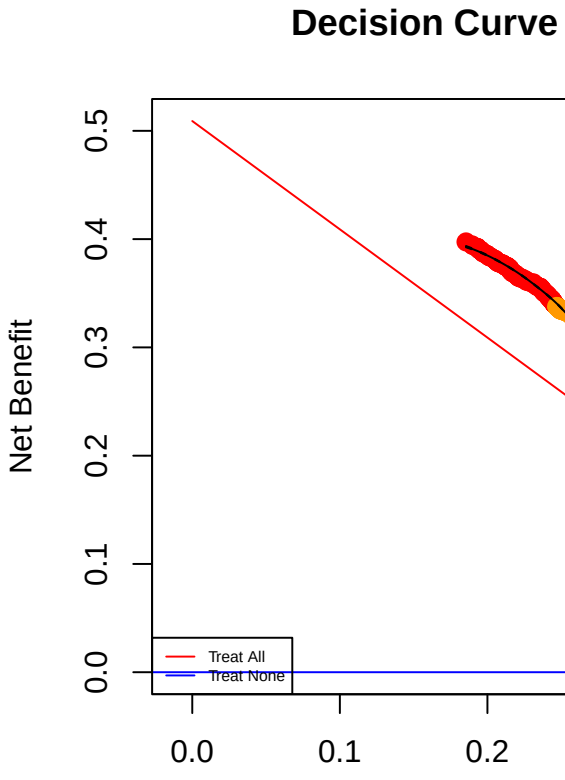
```
timeinterval <- 5 # Five years

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")
```

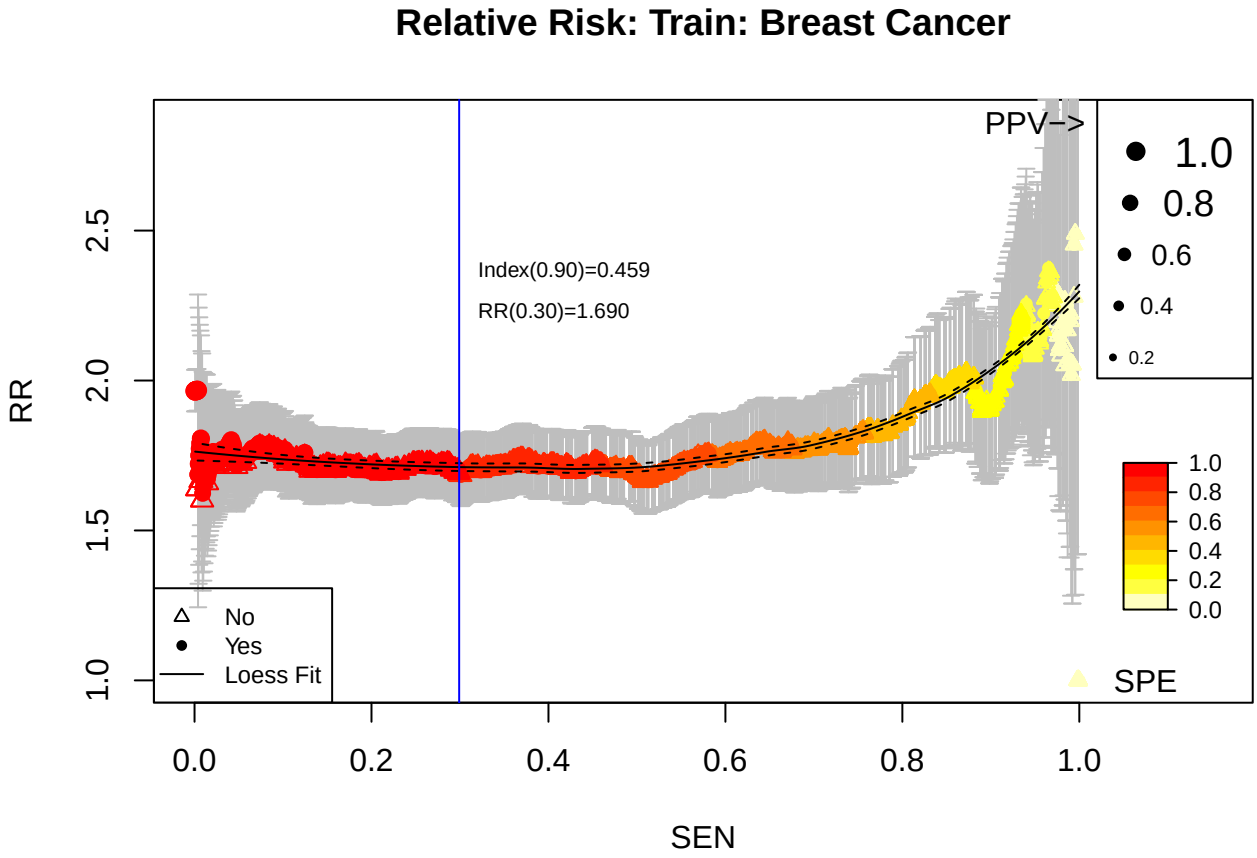
Table 4: Initial Parameters

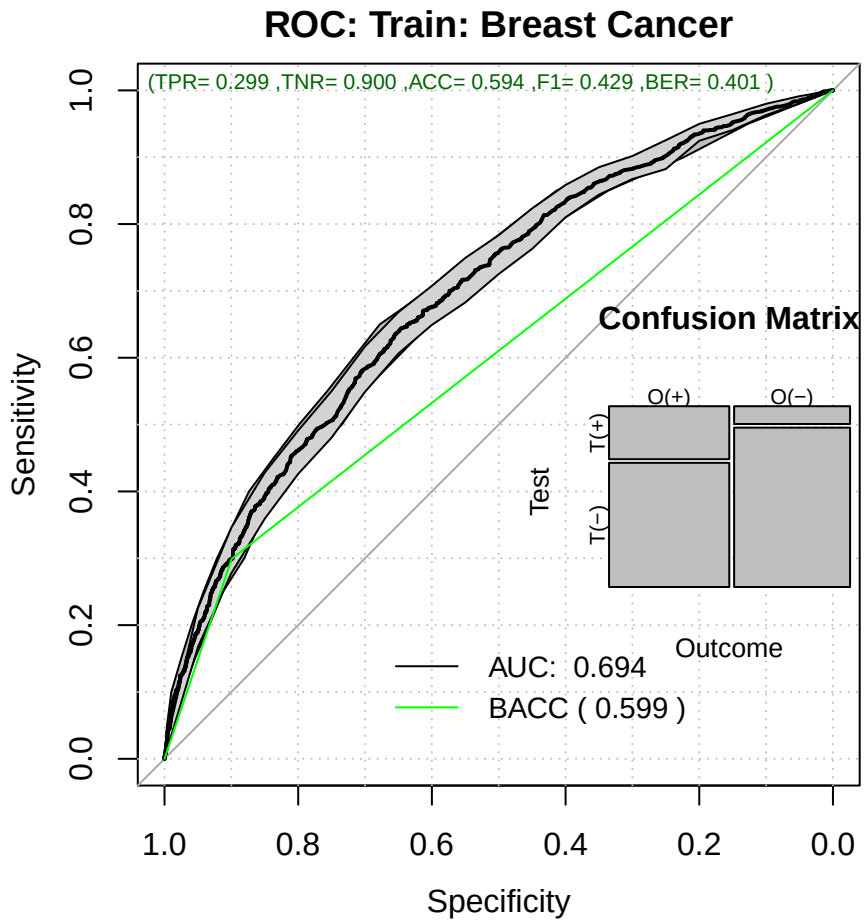
| h0 | timeinterval |
|---|---|
| 0.429 | 5 |

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

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

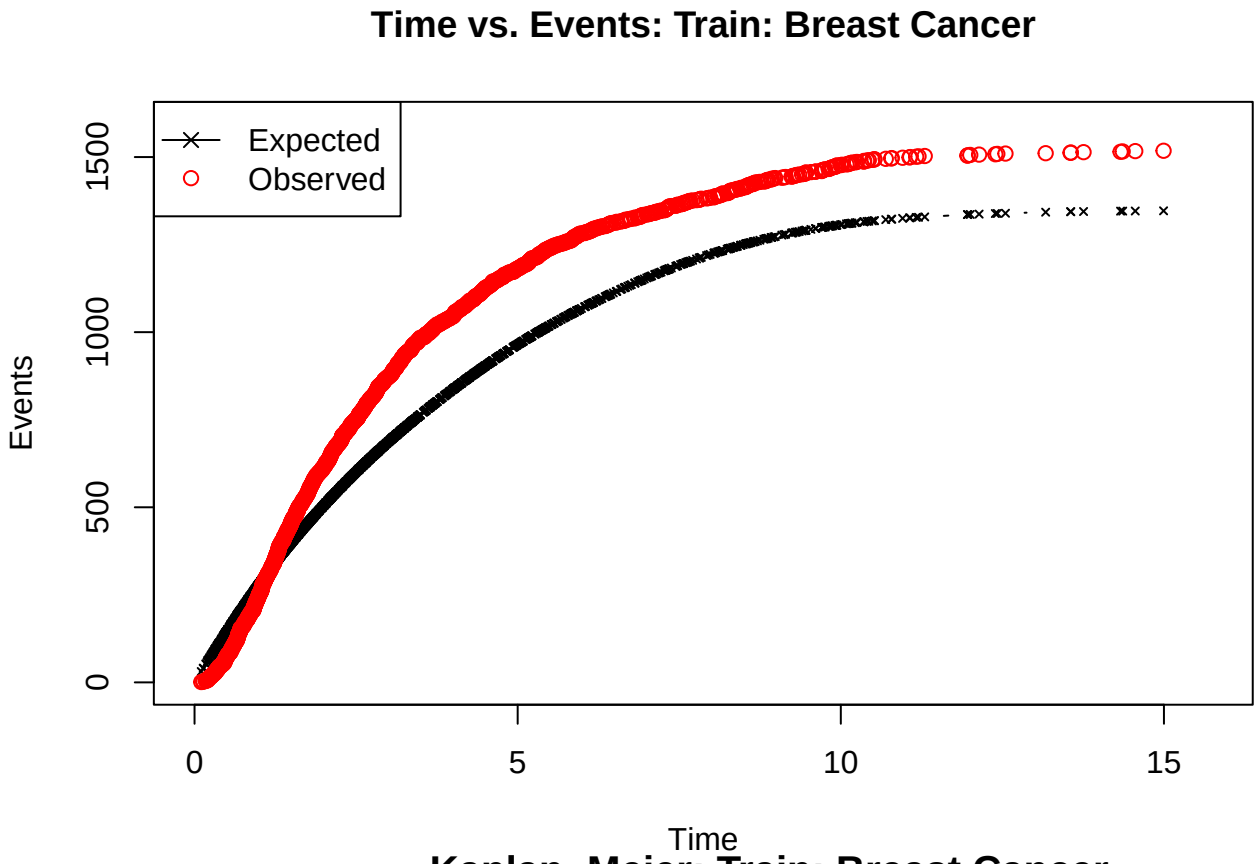


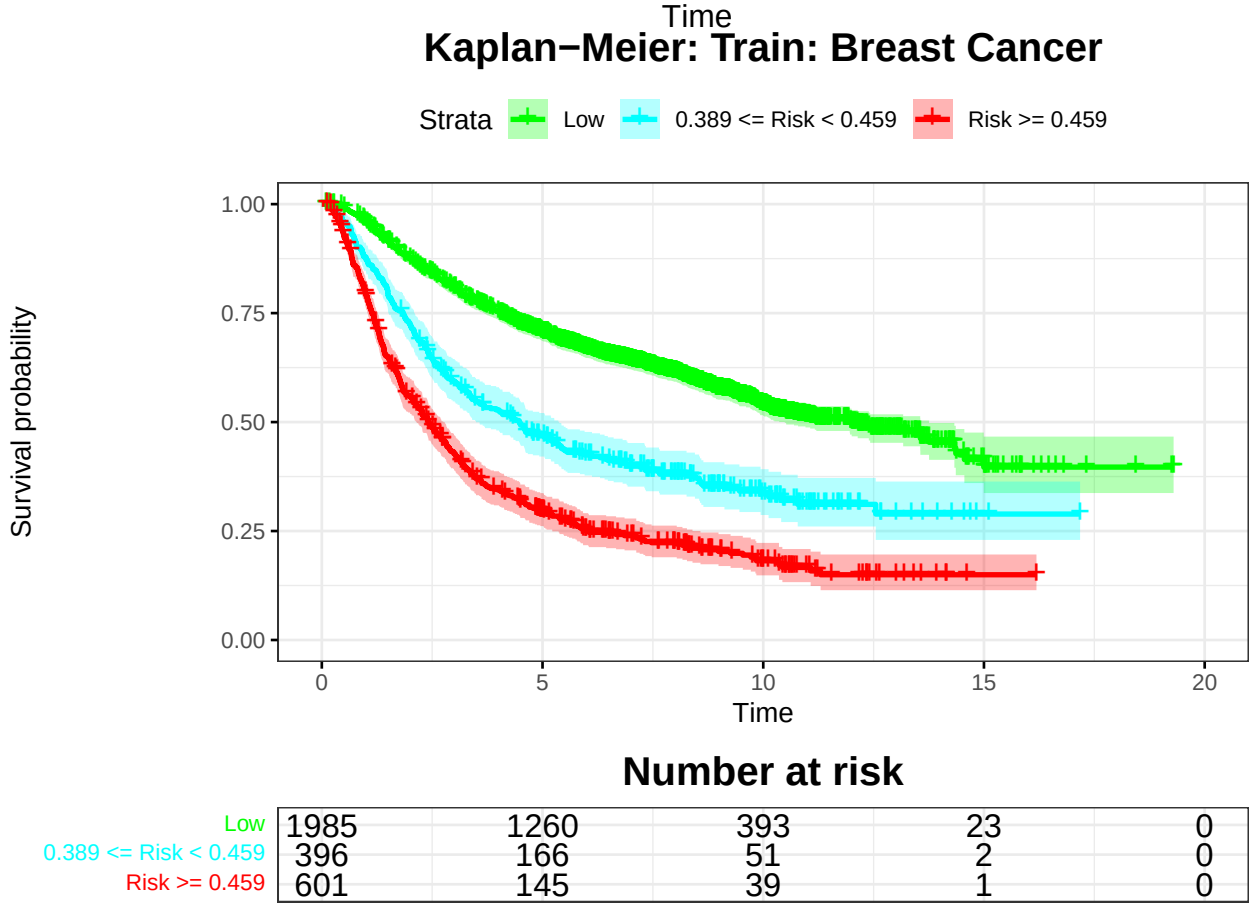




Relative Risk: Train: Breast Cancer
PPV–>
1.0
0.8
0.6
0.4
0.2
Index(0.90)=0.459
RR(0.30)=1.690
1.0
0.8
0.6
0.4
0.2
0.0
No
Yes
Loess Fit
SPE
RR
1.0
1.5
2.0
2.5
0.0
0.2
0.4
0.6
0.8
1.0
SEN




ROC: Train: Breast Cancer




## Number at risk

| | | | | | |
|---|---|---|---|---|---|
| Low | 1985 | 1260 | 393 | 23 | 0 |
| 0.389 <= Risk < 0.459 | 396 | 166 | 51 | 2 | 0 |
| Risk >= 0.459 | 601 | 145 | 39 | 1 | 0 |

As we can see the Observed probability as well as the Time vs. Events are not calibrated.

**Uncalibrated Performance Report**

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

Table 5: O/E Ratio

| est | lower | upper |
|---|---|---|
| 1.13 | 1.07 | 1.19 |

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

Table 6: O/E Ratio

| mean | 50% | 2.5% | 97.5% |
|---|---|---|---|
| 1.13 | 1.13 | 1.12 | 1.14 |

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

Table 7: O/Acum Ratio

| mean | 50% | 2.5% | 97.5% |
|---|---|---|---|
| 1.34 | 1.34 | 1.34 | 1.34 |

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

| mean.C Index | median | lower | upper |
|---|---|---|---|
| 0.676 | 0.677 | 0.663 | 0.691 |

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

Table 9: ROC AUC

| est | lower | upper |
|---|---|---|
| 0.694 | 0.675 | 0.713 |

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

Table 10: Sensitivity

| est | lower | upper |
|---|---|---|
| 0.299 | 0.276 | 0.323 |

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

Table 11: Specificity

| est | lower | upper |
|---|---|---|
| 0.9 | 0.883 | 0.915 |

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

Table 12: Probability Thresholds

| 90% | 80% |
|---|---|
| 0.459 | 0.389 |

```
pander::pander(t(rrAnalysisTrain$RR_atP),caption="Risk Ratio")
```

Table 13: Risk Ratio

| est | lower | upper |
|---|---|---|
| 1.69 | 1.59 | 1.8 |

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

Table 14: Logrank test Chisq = 465.079317 on 2 degrees of freedom, p = 0.000000

| | N | Observed | Expected | (O-E)^2/E | (O-E)^2/V |
|---|---|---|---|---|---|
| **class=0** | 1985 | 816 | 1144 | 93.9 | 385.7 |
| **class=1** | 396 | 248 | 177 | 28.0 | 31.8 |
| **class=2** | 601 | 454 | 197 | 336.3 | 391.3 |

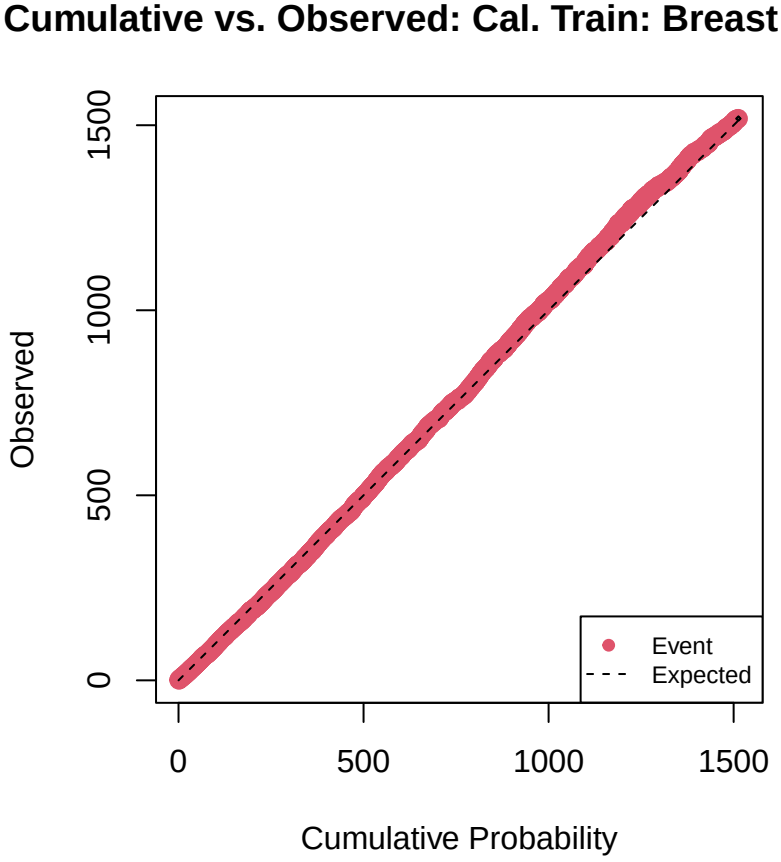
### Cox Calibration

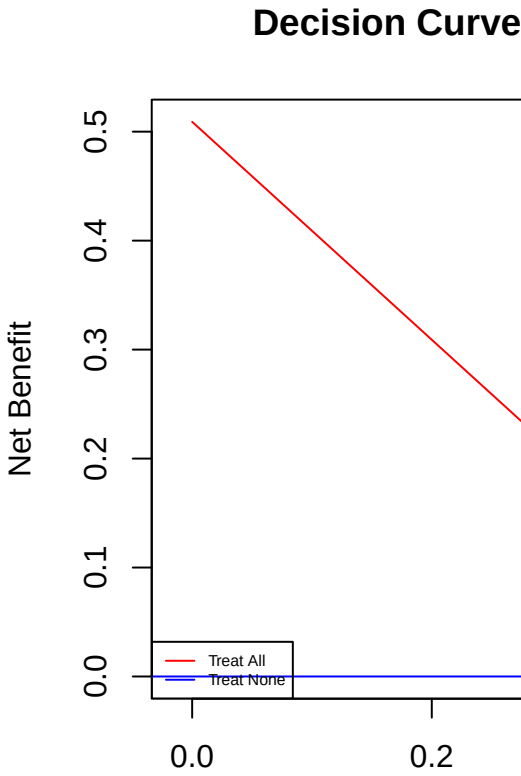
```
op <- par(no.readonly = TRUE)


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


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

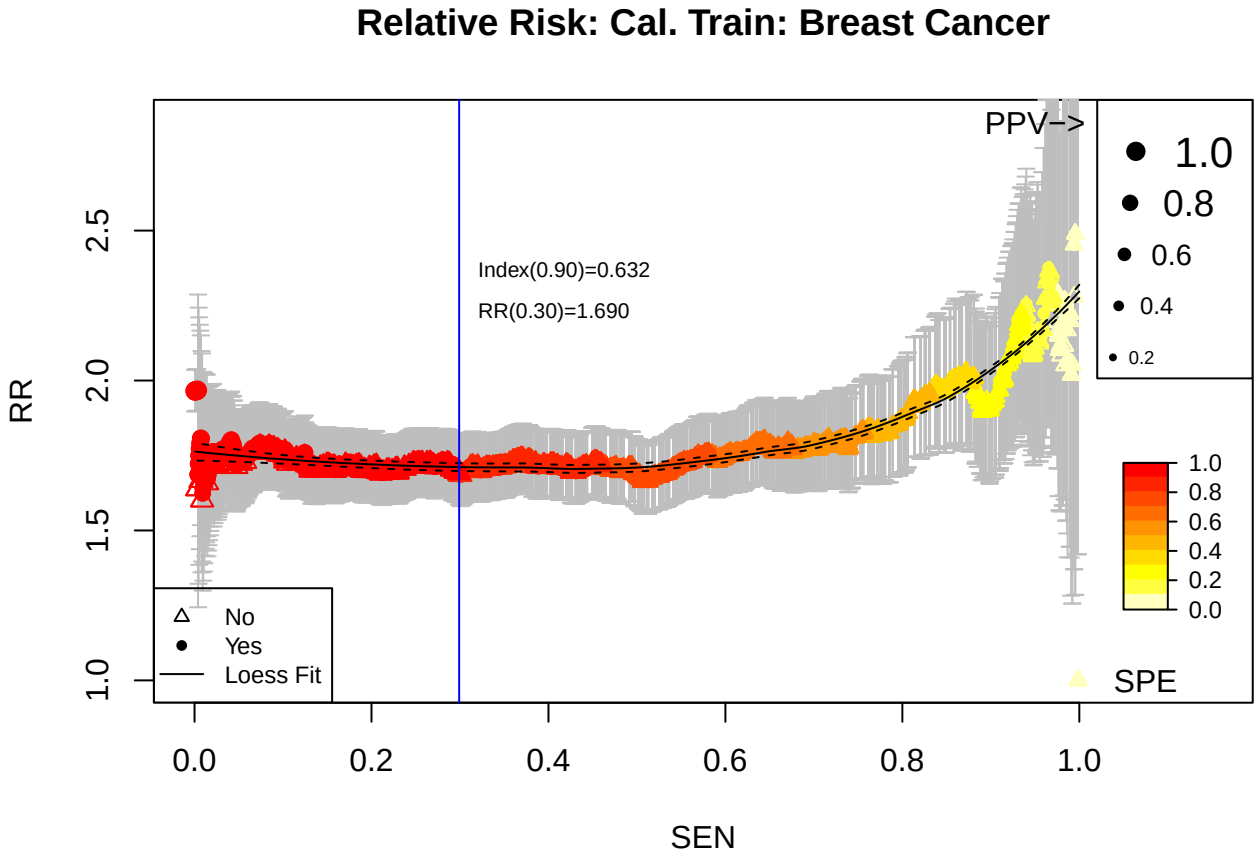
| h0 | Gain | DeltaTime |
|---|---|---|
| 0.698 | 1.35 | 6.97 |

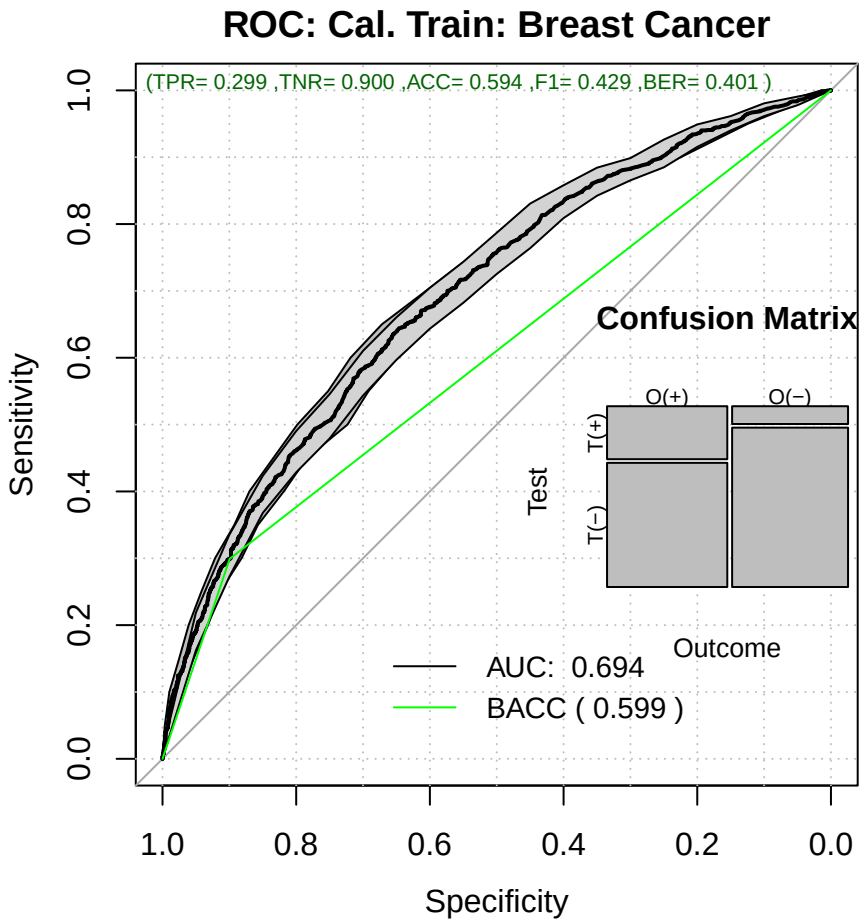
**The RRplot() of the calibrated model**

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

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


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

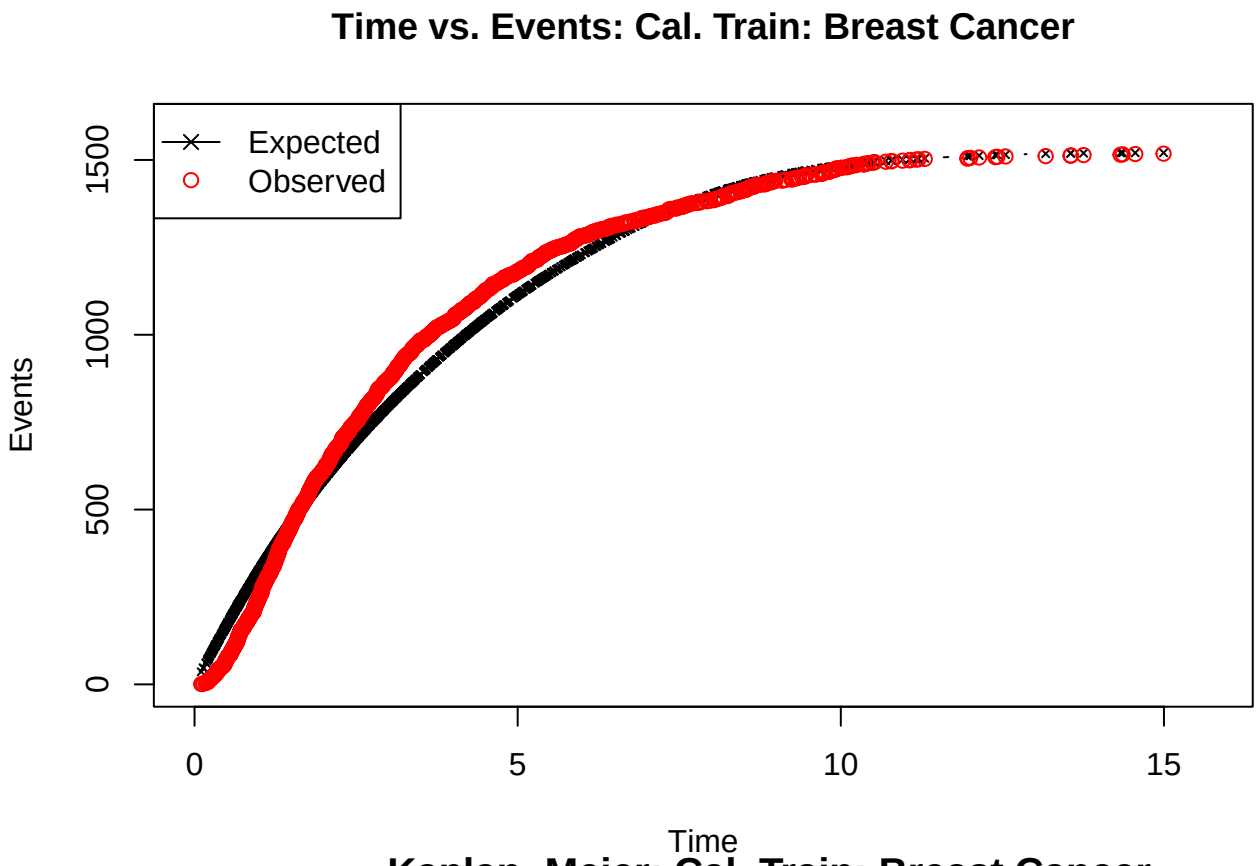


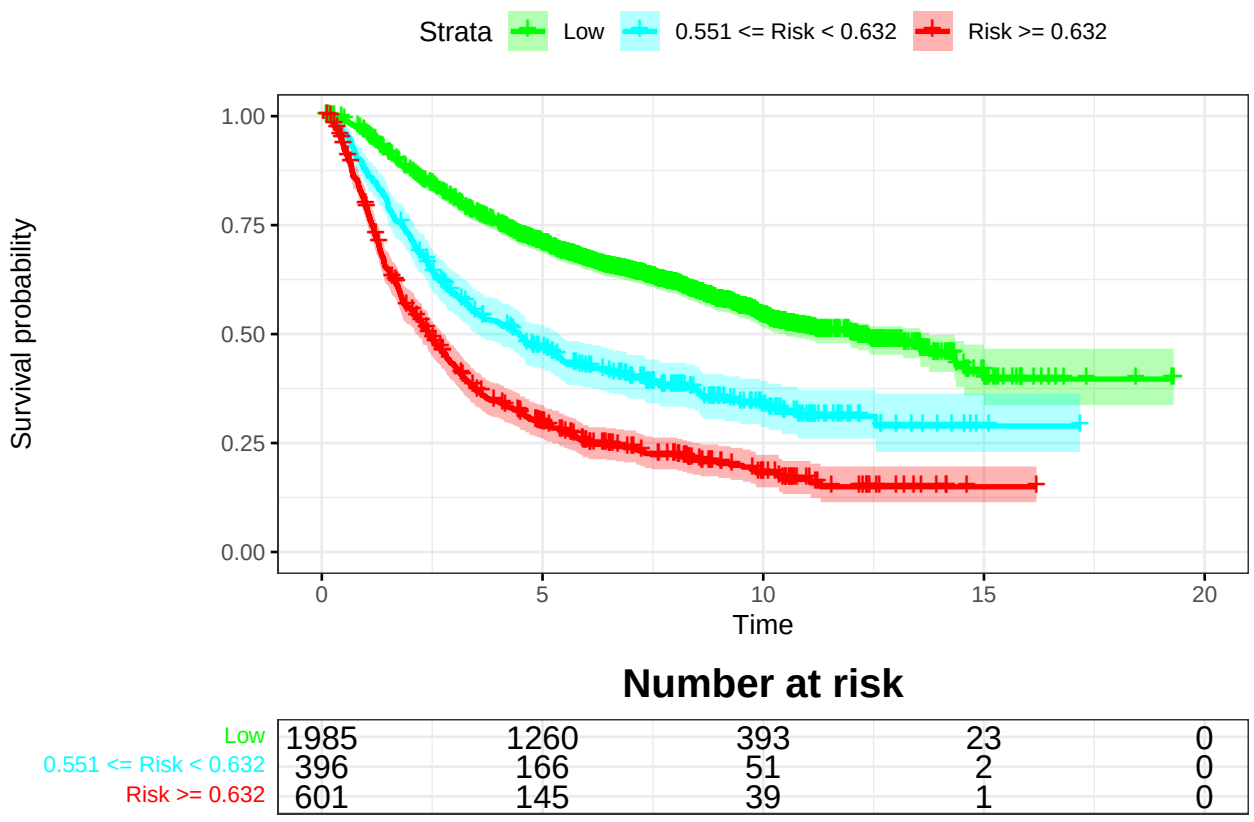




Relative Risk: Cal. Train: Breast Cancer
PPV–>
1.0
0.8
0.6
0.4
0.2
Index(0.90)=0.632
RR(0.30)=1.690
1.0
0.8
0.6
0.4
0.2
0.0
No
Yes
Loess Fit
SPE
RR
1.0
1.5
2.0
2.5
0.0
0.2
0.4
0.6
0.8
1.0
SEN




ROC: Cal. Train: Breast Cancer




## Number at risk

| | | | | | |
|---|---|---|---|---|---|
| Low | 1985 | 1260 | 393 | 23 | 0 |
| 0.551 <= Risk < 0.632 | 396 | 166 | 51 | 2 | 0 |
| Risk >= 0.632 | 601 | 145 | 39 | 1 | 0 |

**Calibrated Train Performance**

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

Table 16: O/E Ratio

| est | lower | upper |
|---|---|---|
| 0.998 | 0.949 | 1.05 |

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

Table 17: O/E Ratio

| mean | 50% | 2.5% | 97.5% |
|---|---|---|---|
| 0.977 | 0.977 | 0.969 | 0.985 |

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

Table 18: O/Acum Ratio

| mean | 50% | 2.5% | 97.5% |
|---|---|---|---|
| 1.01 | 1.01 | 1.01 | 1.01 |

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

| mean.C Index | median | lower | upper |
|---|---|---|---|
| 0.676 | 0.676 | 0.662 | 0.691 |

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

Table 20: ROC AUC

| est | lower | upper |
|---|---|---|
| 0.694 | 0.675 | 0.713 |

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

Table 21: Sensitivity

| est | lower | upper |
|---|---|---|
| 0.299 | 0.276 | 0.323 |

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

Table 22: Specificity

| est | lower | upper |
|---|---|---|
| 0.9 | 0.883 | 0.915 |

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

Table 23: Probability Thresholds

| 90% | 80% |
|---|---|
| 0.632 | 0.551 |

```
pander::pander(t(rrAnalysisTrain$RR_atP),caption="Risk Ratio")
```

Table 24: Risk Ratio

| est | lower | upper |
|---|---|---|
| 1.69 | 1.59 | 1.8 |

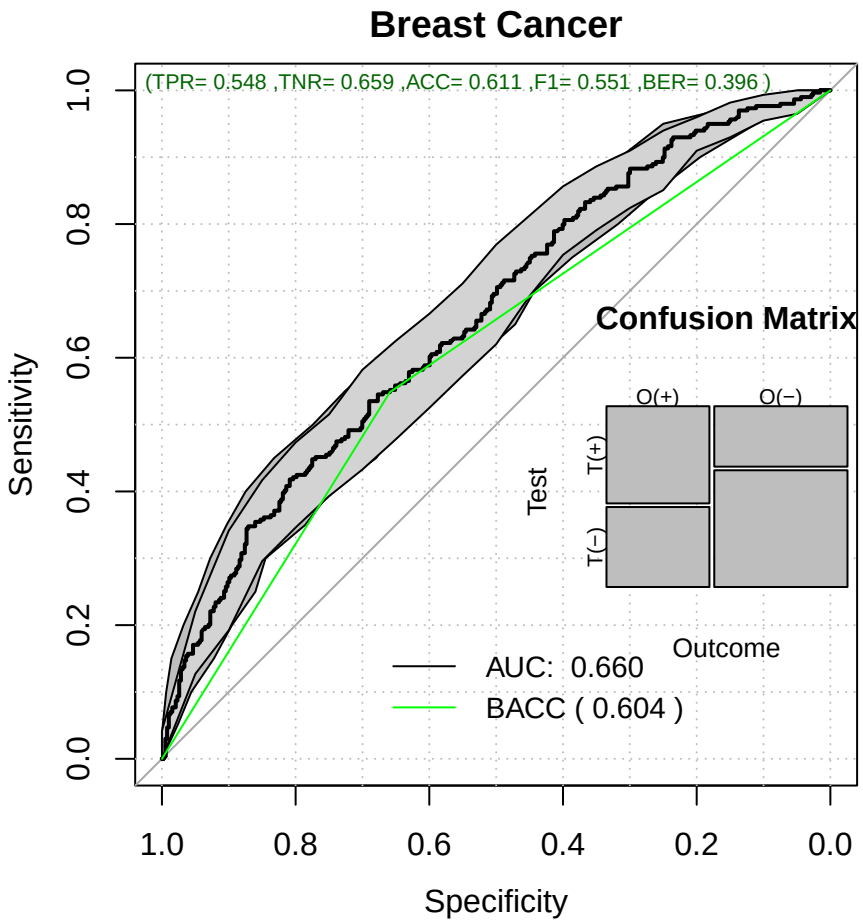
```
pander::pander(rrAnalysisTrain$sufdif,caption="Logrank test")
```

Table 25: Logrank test Chisq = 465.079317 on 2 degrees of freedom, p = 0.000000

| | N | Observed | Expected | (O-E)^2/E | (O-E)^2/V |
|---|---|---|---|---|---|
| **class=0** | 1985 | 816 | 1144 | 93.9 | 385.7 |
| **class=1** | 396 | 248 | 177 | 28.0 | 31.8 |
| **class=2** | 601 | 454 | 197 | 336.3 | 391.3 |

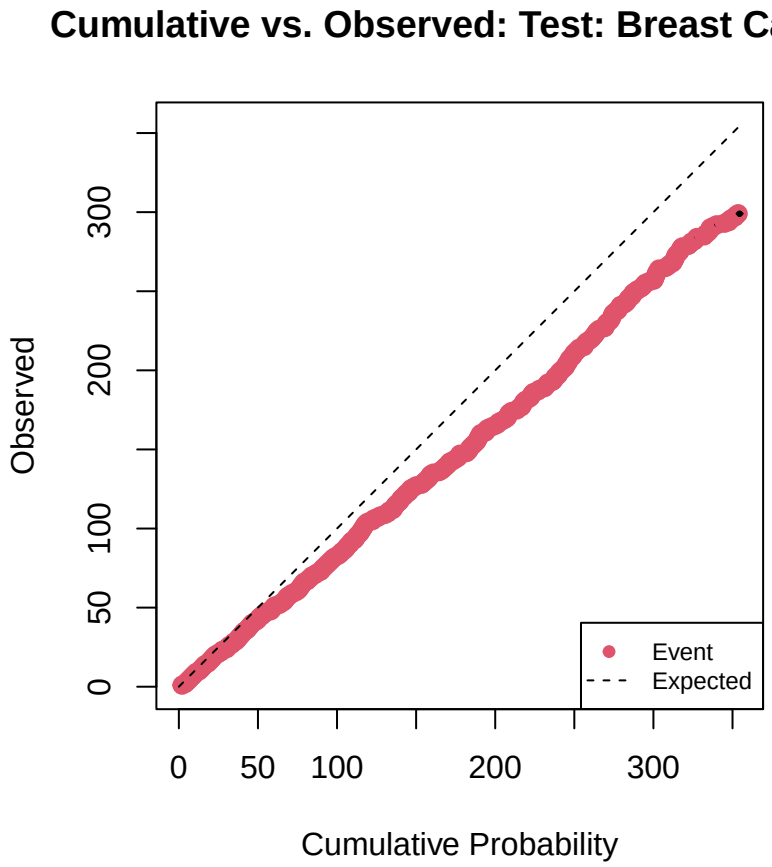
## Performance on the external data set

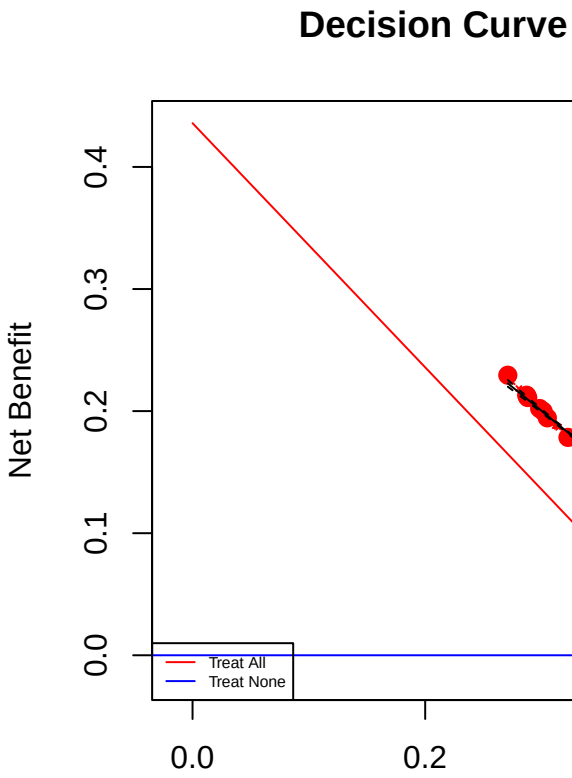
```
index <- predict(ml,dataBrestCancerTest)
pp <- predictionStats_binary(cbind(dataBrestCancerTest$status,index),plotname="Breast Cancer")
```

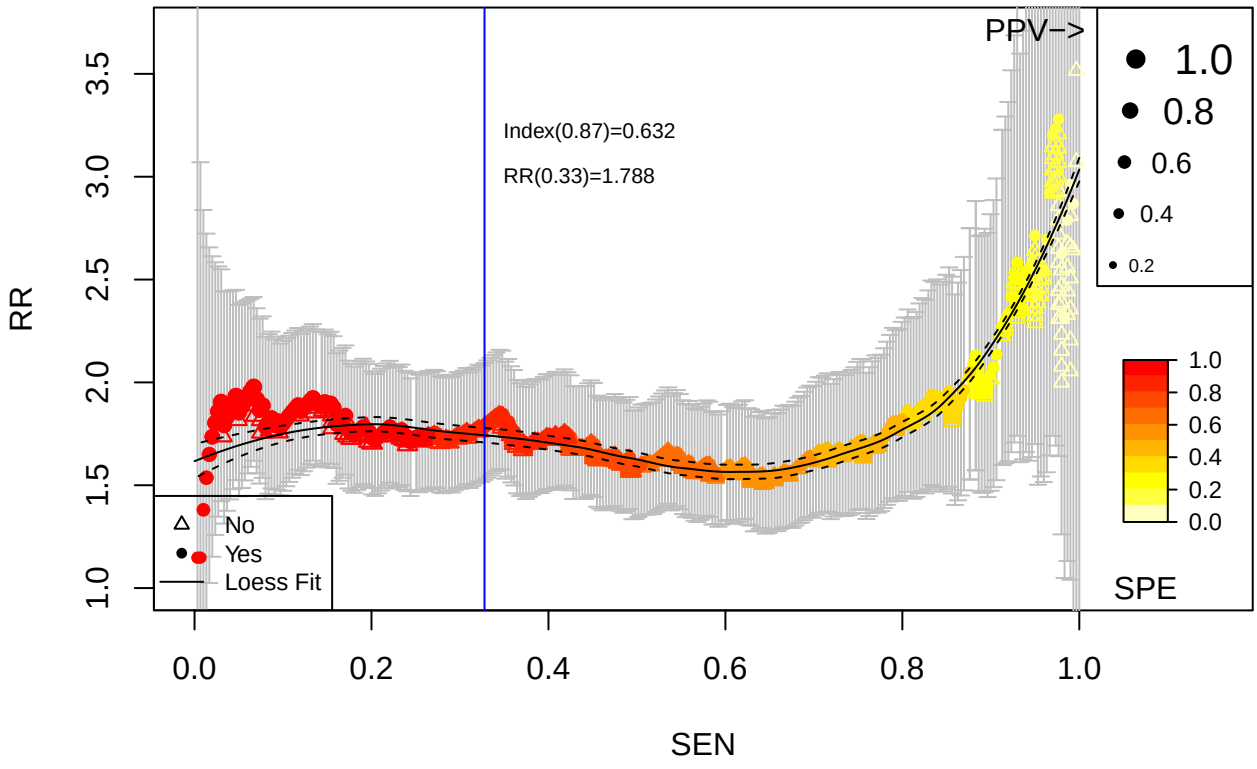


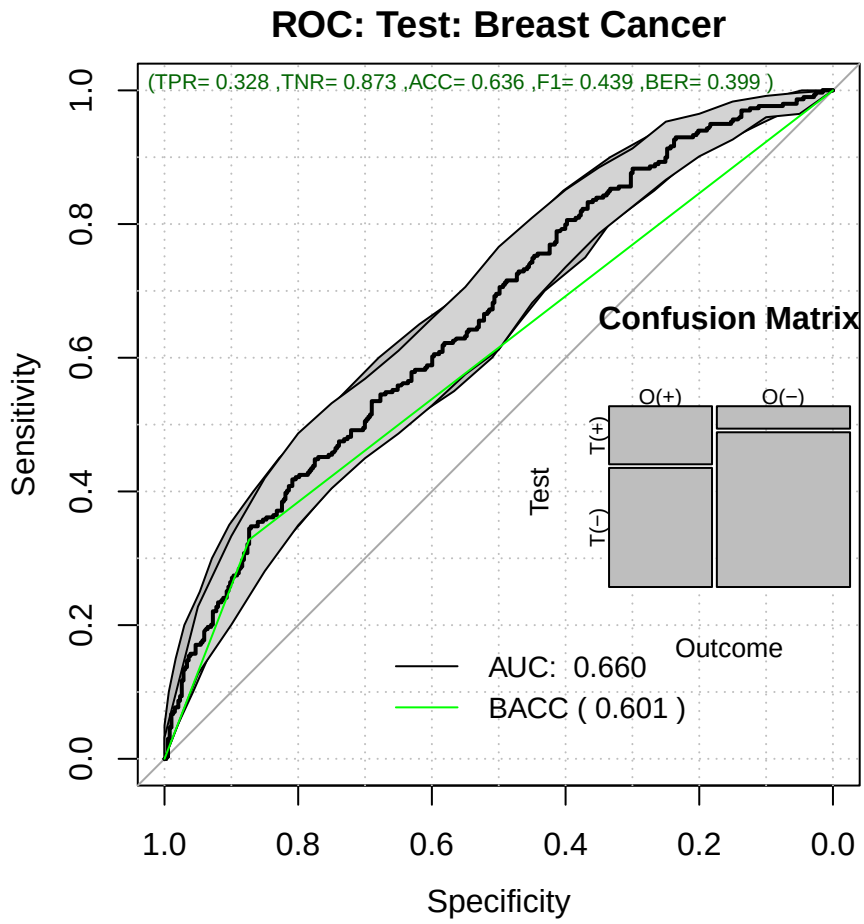

Breast Cancer

```
par(op)


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

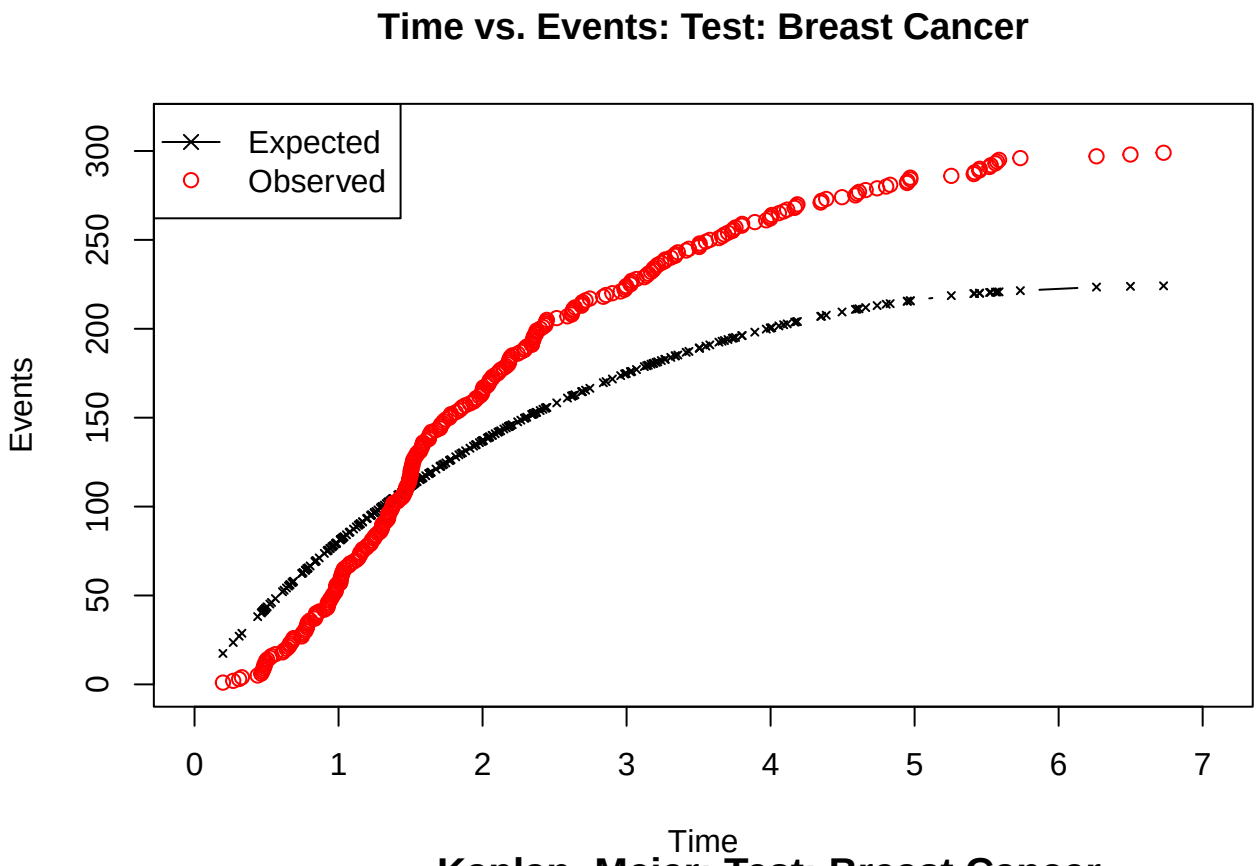

Cumulative vs. Observed: Test: Breast Cancer
Observed
0
50
100
200
300
Event
Expected
Cumulative Probability

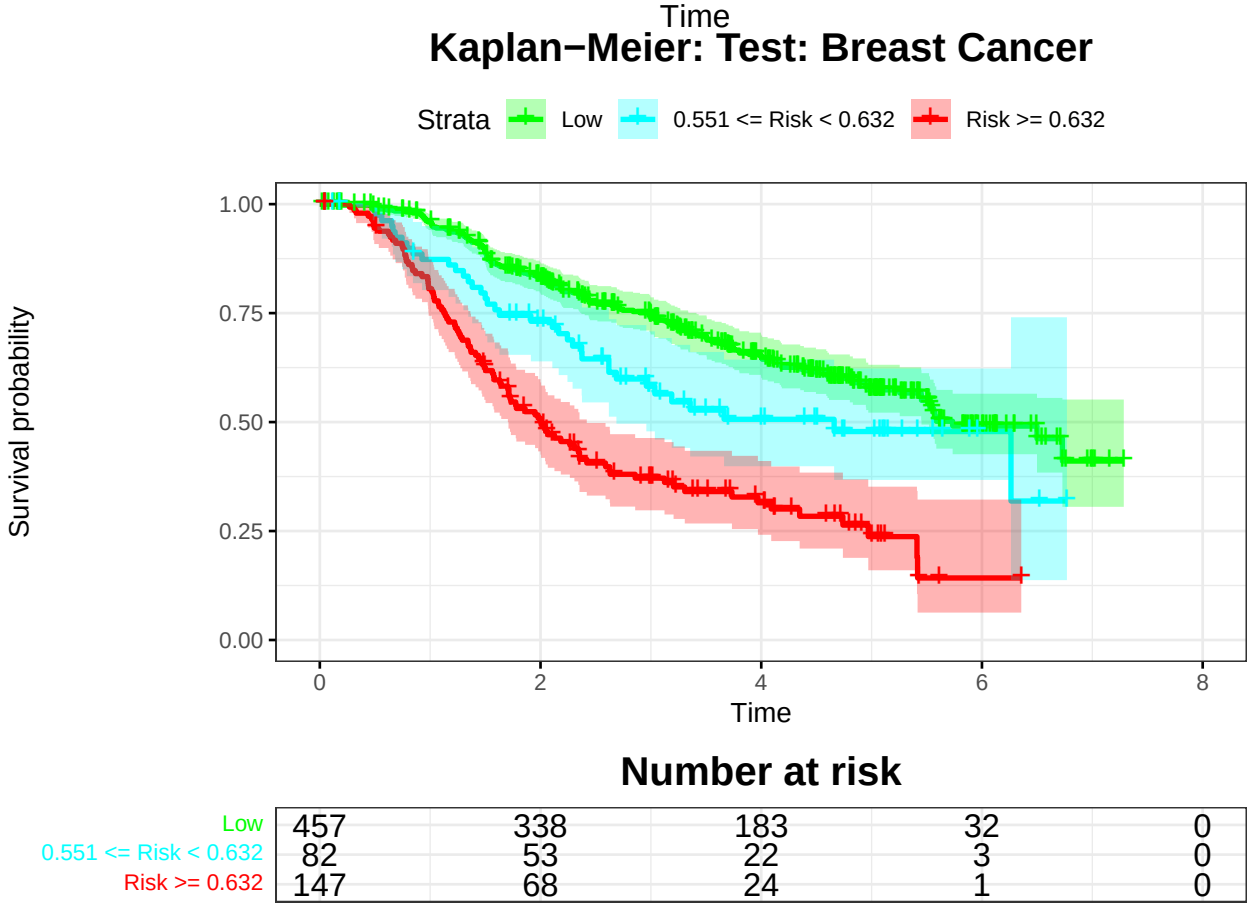

Decision Curve
Net Benefit
0.0
0.1
0.2
0.3
0.4
Treat All
Treat None
0.0
0.2


Relative Risk: Test: Breast Cancer
RR
1.0
1.5
2.0
2.5
3.0
3.5
PPV–>
1.0
0.8
0.6
0.4
0.2
Index(0.87)=0.632
RR(0.33)=1.788
No
Yes
Loess Fit
1.0
0.8
0.6
0.4
0.2
0.0
SPE
0.0
0.2
0.4
0.6
0.8
1.0
SEN




ROC: Test: Breast Cancer




## Number at risk

| | | | | | |
|---|---|---|---|---|---|
| Low | 457 | 338 | 183 | 32 | 0 |
| 0.551 <= Risk < 0.632 | 82 | 53 | 22 | 3 | 0 |
| Risk >= 0.632 | 147 | 68 | 24 | 1 | 0 |

```
par(op)
```

### External Data Report

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

Table 26: O/E Ratio

| est | lower | upper |
|---|---|---|
| 1.33 | 1.19 | 1.49 |

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

- **C Index**: *0.664*
- **Dxy**: *0.328*
- **S.D.**: *0.0311*
- **n**: *686*
- **missing**: *0*
- **uncensored**: *299*
- **Relevant Pairs**: *266144*
- **Concordant**: *176737*
- **Uncertain**: *203702*
- **cstatCI**:

| mean.C Index | median | lower | upper |
|---|---|---|---|
| 0.664 | 0.664 | 0.633 | 0.695 |

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

Table 28: ROC AUC

| est | lower | upper |
|---|---|---|
| 0.66 | 0.619 | 0.7 |

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

Table 29: Sensitivity

| est | lower | upper |
|---|---|---|
| 0.328 | 0.275 | 0.384 |

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

Table 30: Specificity

| est | lower | upper |
|---|---|---|
| 0.873 | 0.836 | 0.905 |

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

Table 31: Probability Thresholds

| 90% | 80% |
|---|---|
| 0.632 | 0.551 |

```
pander::pander(t(rrCoxTestAnalysis$RR_atP),caption="Risk Ratio")
```

Table 32: Risk Ratio

| est | lower | upper |
|---|---|---|
| 1.79 | 1.53 | 2.09 |

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

Table 33: Logrank test Chisq = 81.471750 on 2 degrees of freedom, p = 0.000000

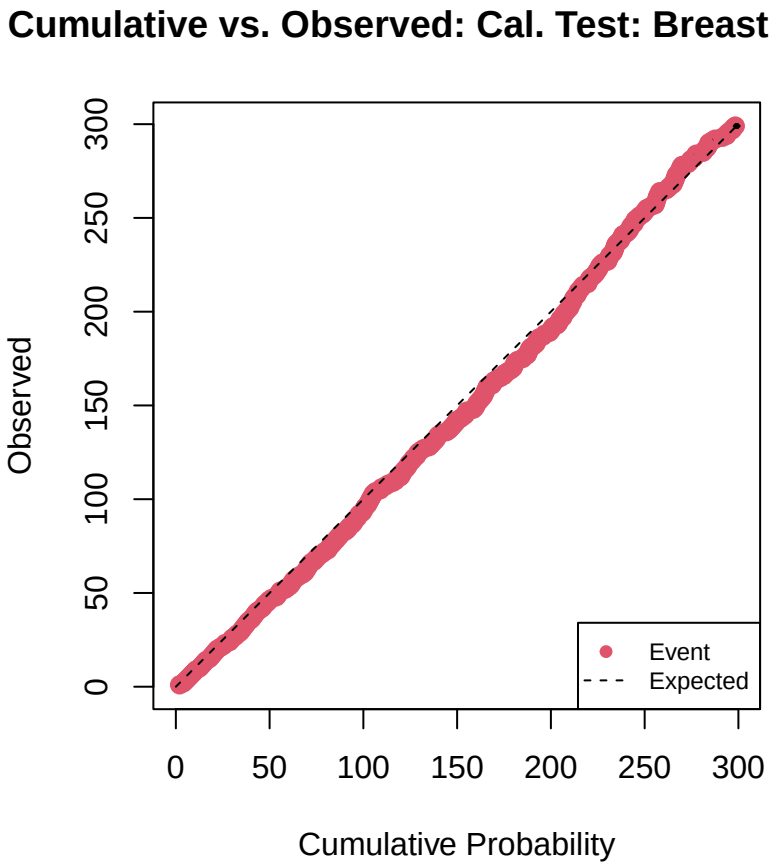
| | N | Observed | Expected | (O-E)^2/E | (O-E)^2/V |
|---|---|---|---|---|---|
| **class=0** | 457 | 164 | 221.4 | 14.888 | 58.181 |
| **class=1** | 82 | 37 | 33.2 | 0.438 | 0.494 |
| **class=2** | 147 | 98 | 44.4 | 64.710 | 77.254 |

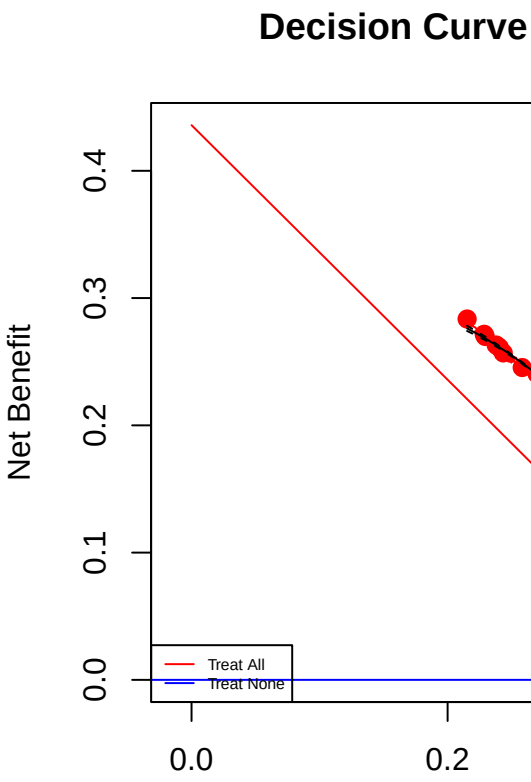
### Calibrating the index on the test data

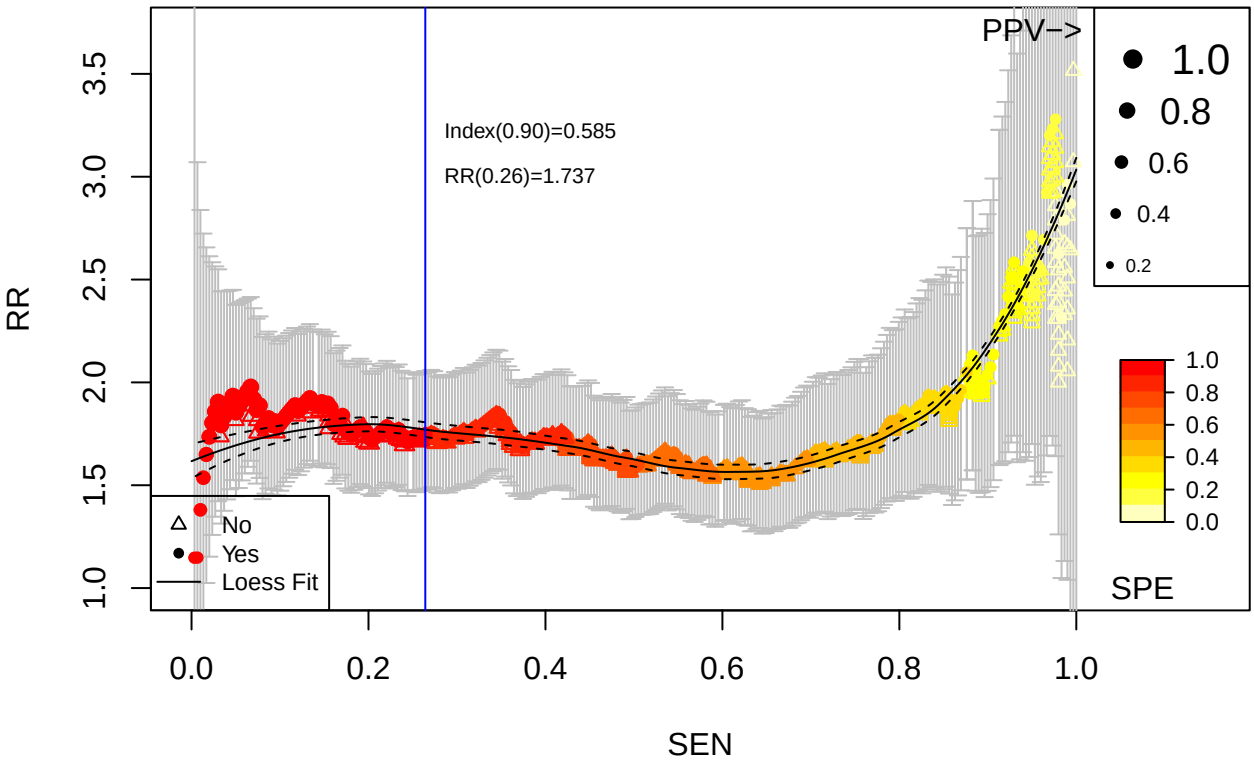
```
calprob <- CoxRiskCalibration(ml,dataBrestCancerTest,"status","time")

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

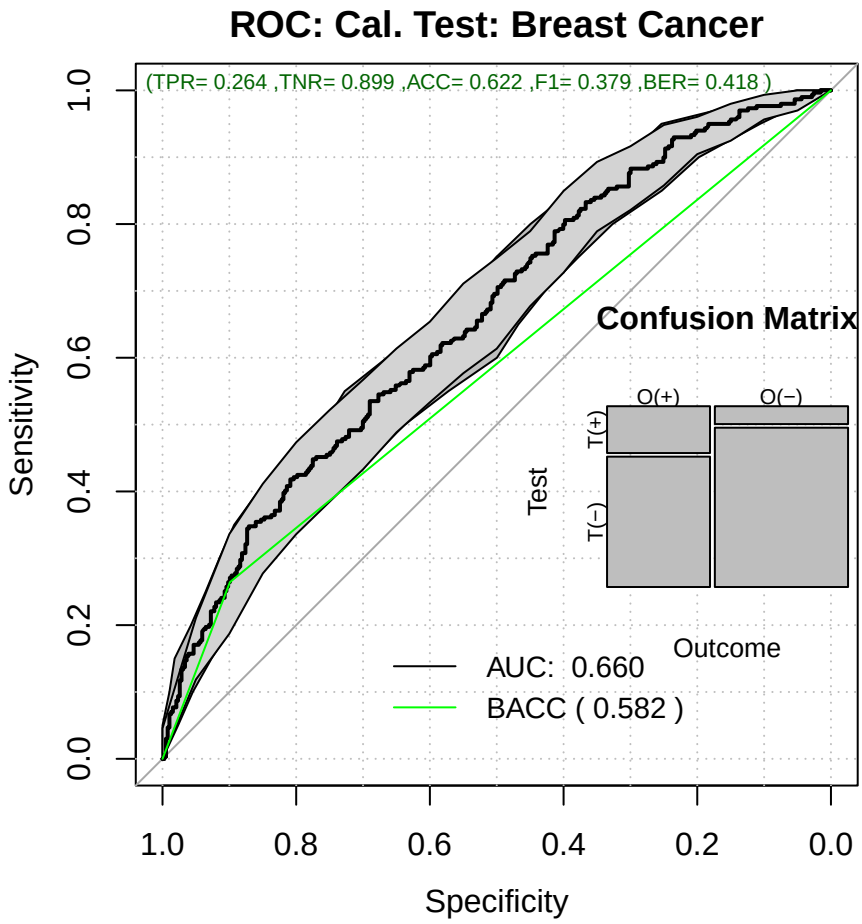
| h0 | Gain | DeltaTime |
|---|---|---|
| 0.535 | 0.925 | 4.87 |

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

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

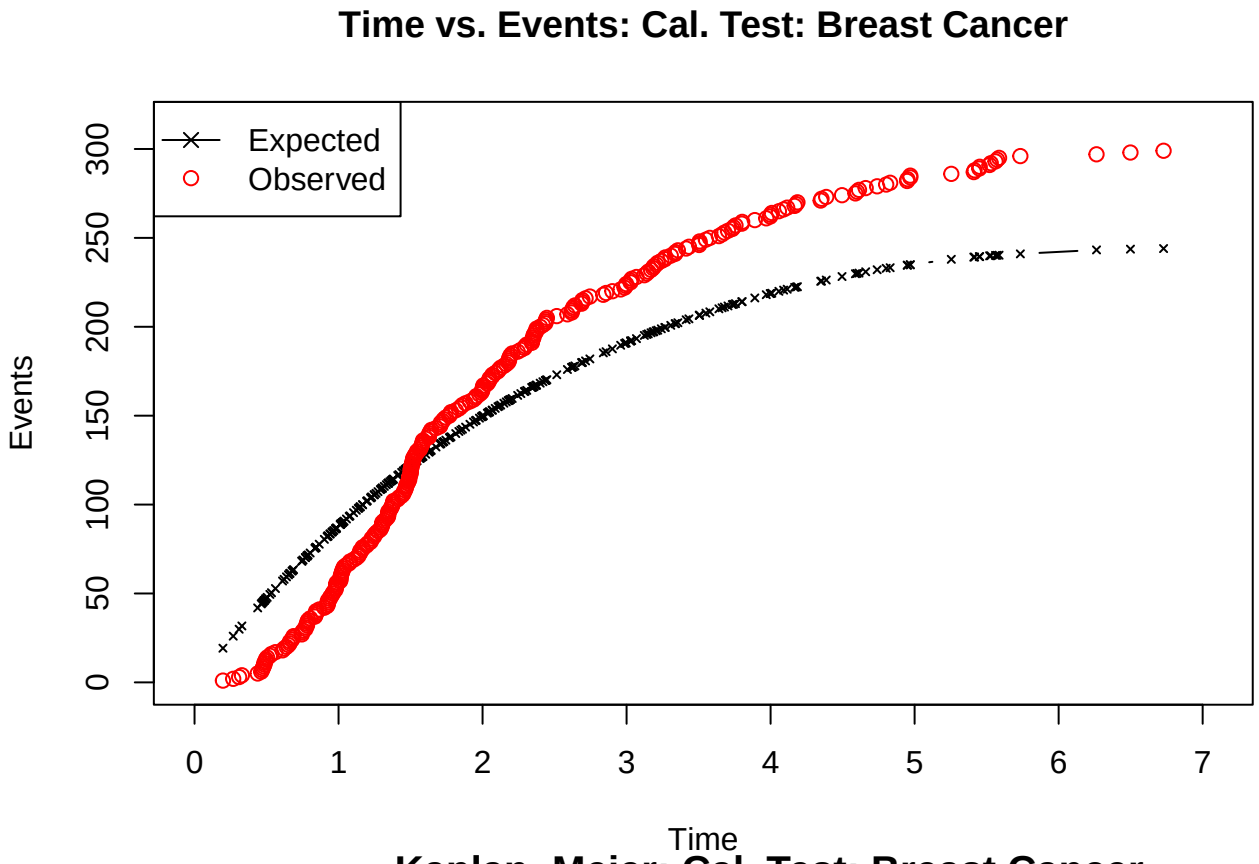

Cumulative vs. Observed: Cal. Test: Breast Cancer
Observed
0
50
100
150
200
250
300
Event
Expected
Cumulative Probability

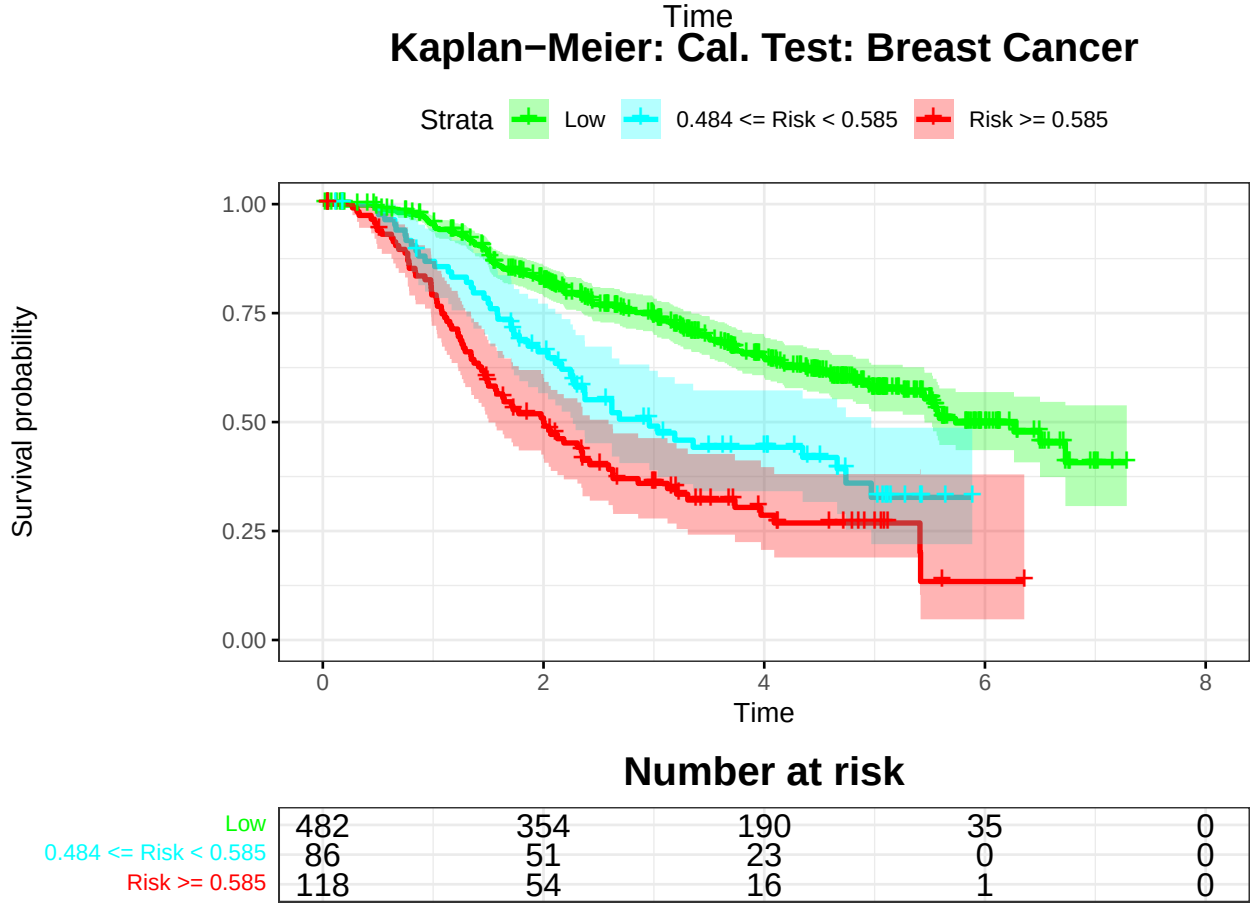

Decision Curve
Net Benefit
0.0
0.1
0.2
0.3
0.4
Treat All
Treat None
0.0
0.2


Relative Risk: Cal. Test: Breast Cancer
RR
1.0
1.5
2.0
2.5
3.0
3.5
PPV–>
1.0
0.8
0.6
0.4
0.2
Index(0.90)=0.585
RR(0.26)=1.737
No
Yes
Loess Fit
1.0
0.8
0.6
0.4
0.2
0.0
SPE
0.0
0.2
0.4
0.6
0.8
1.0
SEN




ROC: Cal. Test: Breast Cancer




## Number at risk

| | | | | | |
|---|---|---|---|---|---|
| Low | 482 | 354 | 190 | 35 | 0 |
| 0.484 <= Risk < 0.585 | 86 | 51 | 23 | 0 | 0 |
| Risk >= 0.585 | 118 | 54 | 16 | 1 | 0 |

**After Calibration Report**

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

Table 35: O/E Ratio

| est | lower | upper |
|---|---|---|
| 1.23 | 1.09 | 1.37 |

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

- **C Index**: *0.664*
- **Dxy**: *0.328*
- **S.D.**: *0.0311*
- **n**: *686*
- **missing**: *0*
- **uncensored**: *299*
- **Relevant Pairs**: *266144*
- **Concordant**: *176737*
- **Uncertain**: *203702*
- **cstatCI**:

| mean.C Index | median | lower | upper |
|---|---|---|---|
| 0.664 | 0.664 | 0.633 | 0.693 |

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

Table 37: ROC AUC

| est | lower | upper |
|---|---|---|
| 0.66 | 0.619 | 0.7 |

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

Table 38: Sensitivity

| est | lower | upper |
|---|---|---|
| 0.264 | 0.215 | 0.318 |

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

Table 39: Specificity

| est | lower | upper |
|---|---|---|
| 0.899 | 0.865 | 0.927 |

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

Table 40: Probability Thresholds

| 90% | 80% |
|---|---|
| 0.585 | 0.484 |

```
pander::pander(t(rrAnalysis$RR_atP),caption="Risk Ratio")
```

Table 41: Risk Ratio

| est | lower | upper |
|---|---|---|
| 1.74 | 1.48 | 2.05 |

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

Table 42: Logrank test Chisq = 80.835092 on 2 degrees of freedom, p = 0.000000

| | N | Observed | Expected | (O-E)^2/E | (O-E)^2/V |
|---|---|---|---|---|---|
| **class=0** | 482 | 173 | 232.4 | 15.20 | 69.5 |
| **class=1** | 86 | 47 | 32.0 | 7.02 | 7.9 |
| **class=2** | 118 | 79 | 34.6 | 57.14 | 65.4 |

## Logistic Model

Here we train a logistic model on the same data set

```
## Only label subjects that present event withing 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)
```

——..

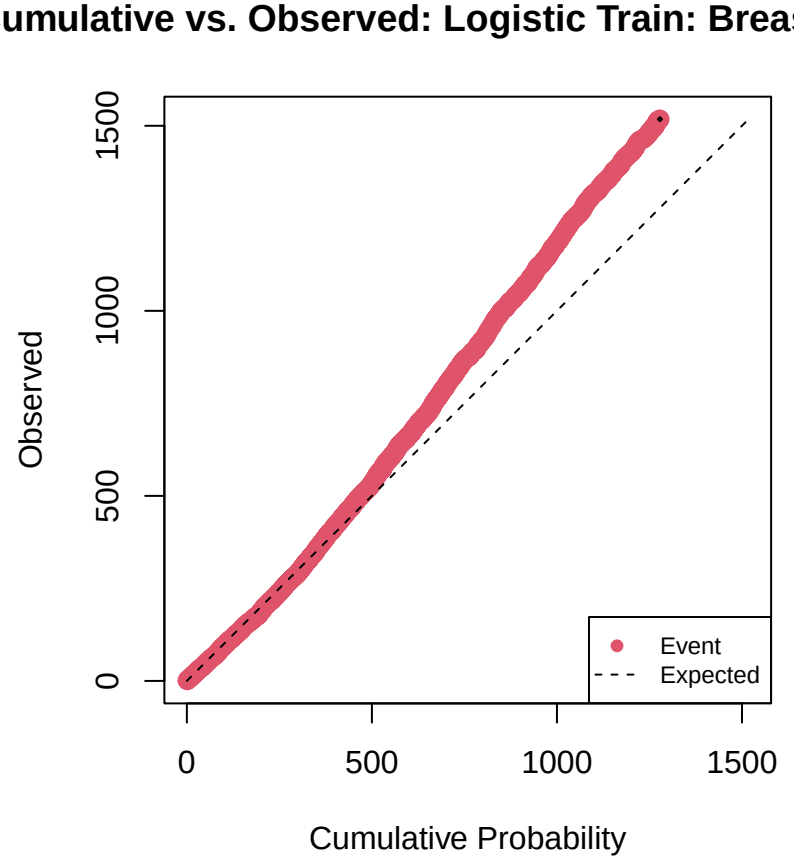
```
sm <- summary(mlog)
pander::pander(sm$coefficients)
```

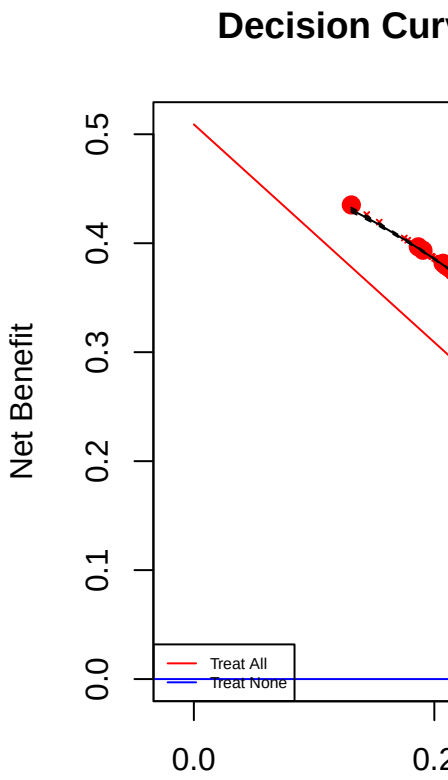
| | Estimate | lower OR | upper | u.Accuracy | Accuracy | full.Accuracy | uAUC | AUC | full.AUC | IDI | NRI | z.IDI | z.NRI | Delta.AUC | Frequency |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **size__nodes** | -3.85e-03 | 1.001 | 1.001 | 1.001 | 0.669 | 0.571 | 0.668 | 0.627 | 0.500 | 0.628 | 0.11230 | 0.636547 | 17.86 | 18.870 | 0.1284901 |
| **nodes** | 4.33e-02 | 1.040 | 1.044 | 1.048 | 0.676 | 0.634 | 0.690 | 0.639 | 0.621 | 0.662 | 0.07110 | 0.57106 | 14.13 | 16.179 | 0.0404941 |
| **grade__nodes** | 7.70e-02 | 1.014 | 1.015 | 1.016 | 0.682 | 0.637 | 0.686 | 0.649 | 0.624 | 0.655 | 0.06580 | 0.54866 | 13.66 | 15.650 | 0.0310871 |
| **age__nodes** | 1.96e-03 | 1.001 | 1.001 | 1.001 | 0.678 | 0.653 | 0.686 | 0.642 | 0.621 | 0.657 | 0.03340 | 0.213129 | 2.39 | 5.710 | 0.0358961 |
| **size__grade** | 1.75e-03 | 1.001 | 1.002 | 1.002 | 0.632 | 0.682 | 0.686 | 0.626 | 0.646 | 0.655 | 0.01787 | 0.294116 | 6.74 | 7.728 | 0.0086481 |
| **age__size** | 8.73e-05 | 1.000 | 1.000 | 1.000 | 0.608 | 0.682 | 0.686 | 0.577 | 0.649 | 0.657 | 0.01530 | 0.291528 | 6.41 | 7.652 | 0.0076001 |
| **grade** | 2.27e-01 | 1.168 | 1.254 | 1.347 | 0.571 | 0.683 | 0.690 | 0.500 | 0.653 | 0.662 | 0.01340 | 0.190366 | 6.20 | 4.983 | 0.0084611 |
| **age__meno** | -6.04e-03 | 0.992 | 0.994 | 0.996 | 0.571 | 0.676 | 0.686 | 0.500 | 0.645 | 0.657 | 0.00782 | 0.080574 | 1.76 | 2.337 | 0.0120651 |
| **age__pgr** | -5.42e-06 | 1.000 | 1.000 | 1.000 | 0.571 | 0.686 | 0.686 | 0.500 | 0.656 | 0.657 | 0.00510 | 0.007454 | 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 | 0.00454 | 0.113732 | 2.60 | 2.960 | 0.0003151 |
| **meno__grade** | 1.02e-01 | 1.045 | 1.107 | 1.173 | 0.571 | 0.683 | 0.686 | 0.500 | 0.652 | 0.657 | 0.00425 | 0.204283 | 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 | 0.455223 | 3.44 | 12.150 | -0.002853 1 |
| **size** | 3.94e-03 | 1.002 | 1.004 | 1.006 | 0.611 | 0.693 | 0.690 | 0.618 | 0.663 | 0.662 | 0.00507 | 0.210563 | 3.42 | 5.600 | -0.001075 1 |
| **meno__pgr** | 3.19e-04 | 1.000 | 1.000 | 1.001 | 0.571 | 0.687 | 0.686 | 0.500 | 0.657 | 0.657 | 0.00316 | 0.059773 | 3.35 | 1.558 | -0.000429 1 |
| **pgr** | -1.07e-04 | 1.000 | 1.000 | 1.000 | 0.571 | 0.689 | 0.686 | 0.500 | 0.659 | 0.655 | 0.00257 | 0.197592 | 2.64 | 5.745 | -0.004123 1 |
| **meno__nodes** | -2.60e-02 | 0.955 | 0.974 | 0.994 | 0.640 | 0.686 | 0.686 | 0.595 | 0.656 | 0.657 | 0.00264 | -0.06329 | 2.59 | -1.645 | 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 | 0.174712 | 2.55 | 5.058 | 0.0012521 |
| **meno__size** | -2.34e-03 | 1.000 | 1.002 | 1.004 | 0.604 | 0.691 | 0.690 | 0.578 | 0.663 | 0.662 | 0.00185 | 0.102227 | 2.43 | 2.662 | -0.001378 1 |

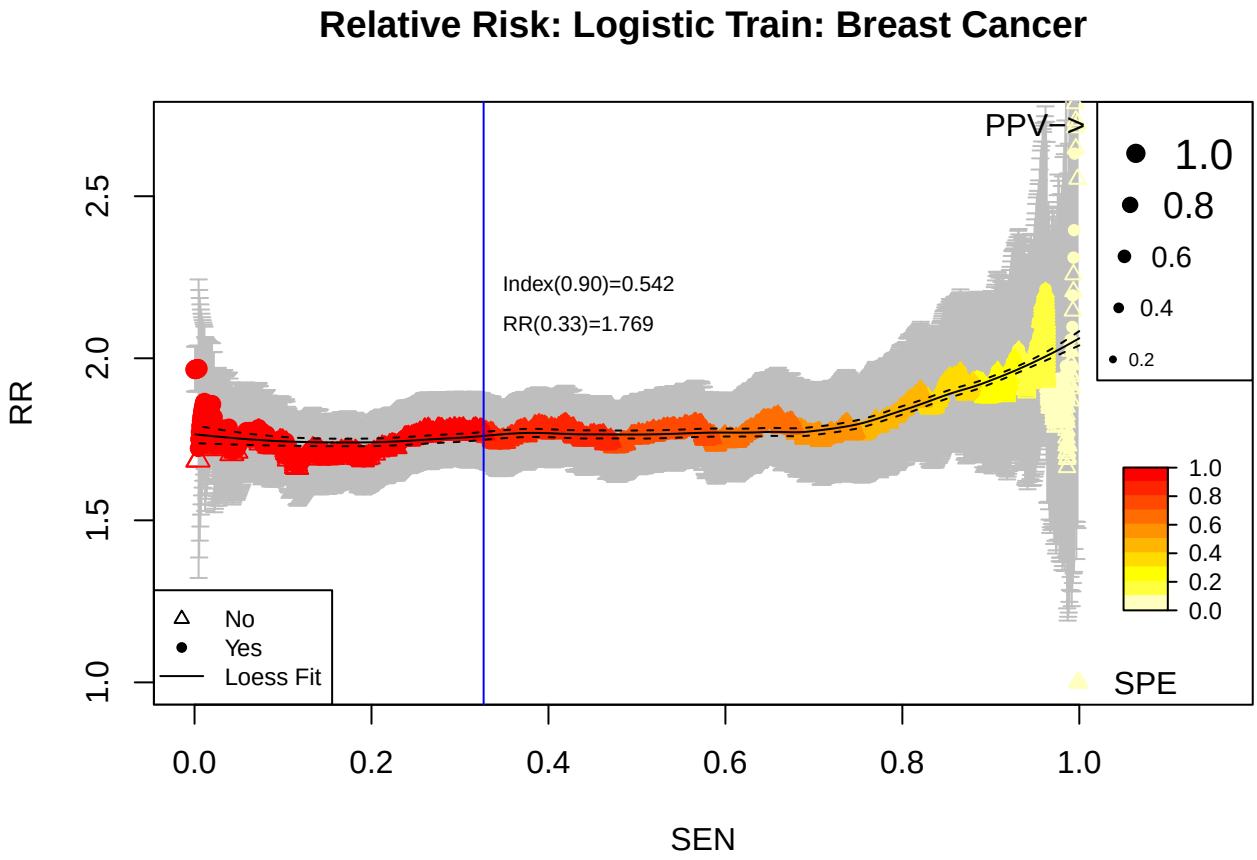
## Logistic Model Performance

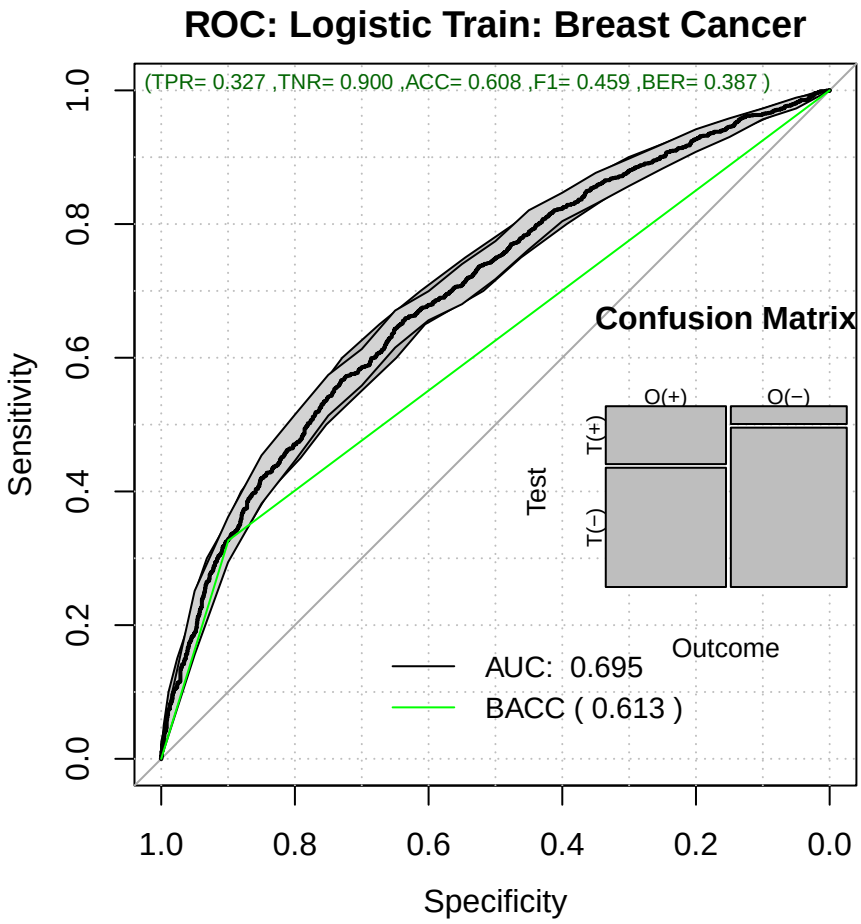
```
op <- par(no.readonly = TRUE)


cprob <- predict(mlog,dataBrestCancerTrain)
```

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

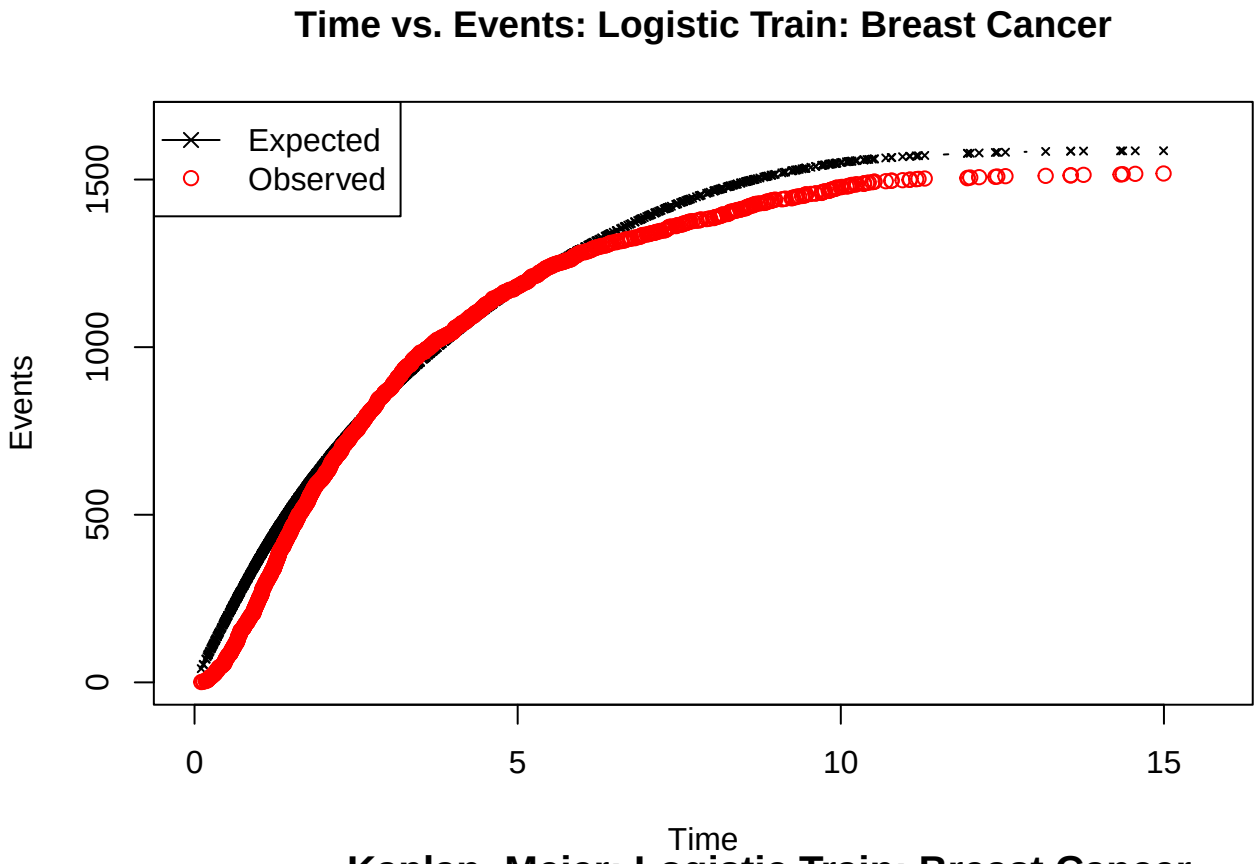


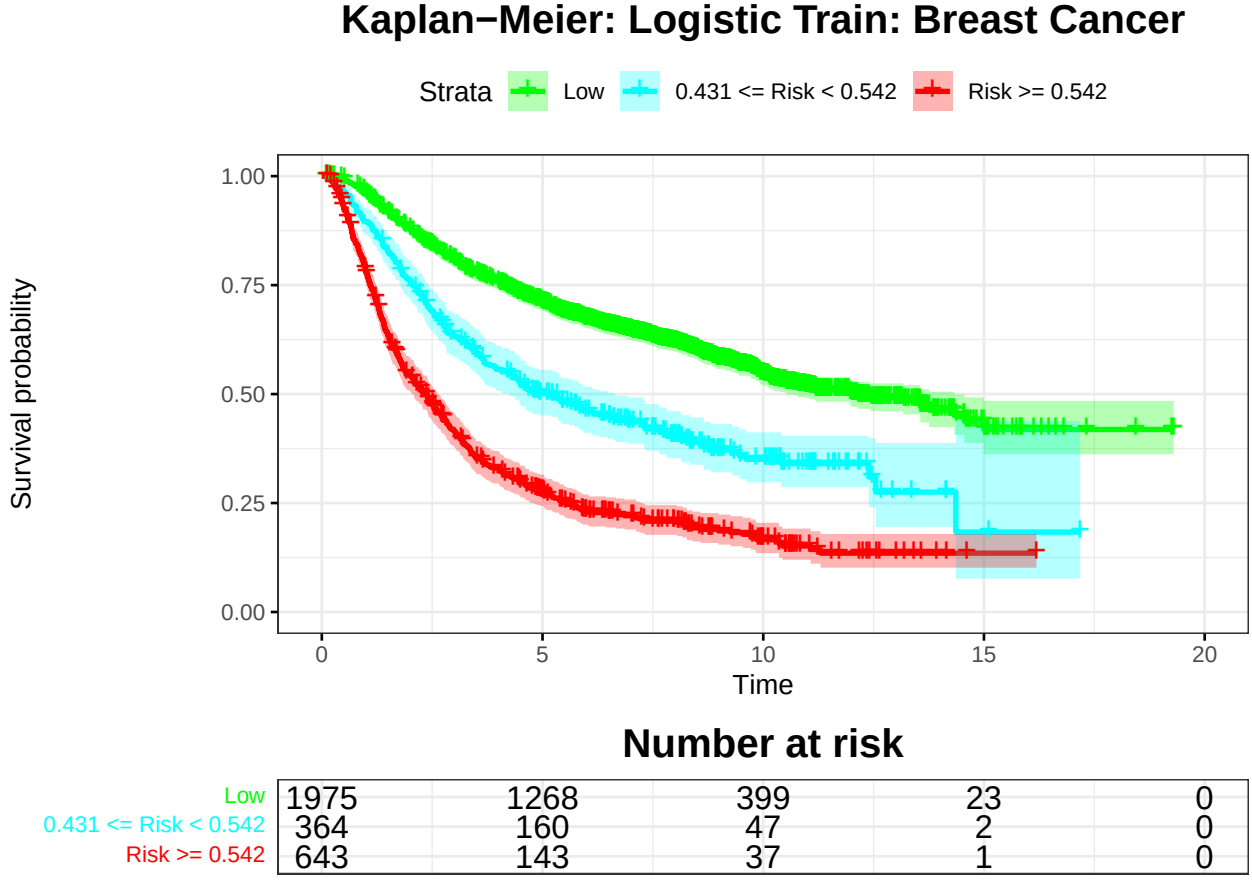




Relative Risk: Logistic Train: Breast Cancer
PPV- >
1.0
0.8
0.6
0.4
0.2
Index(0.90)=0.542
RR(0.33)=1.769
1.0
0.8
0.6
0.4
0.2
0.0
No
Yes
Loess Fit
SPE
RR
2.5
2.0
1.5
1.0
0.0
0.2
0.4
0.6
0.8
1.0
SEN




ROC: Logistic Train: Breast Cancer


Time vs. Events: Logistic Train: Breast Cancer
Expected
Observed
Events
0
500
1000
1500
0
5
10
15
Time


Kaplan−Meier: Logistic Train: Breast Cancer
Strata
Low
0.431 <= Risk < 0.542
Risk >= 0.542
Survival probability
1.00
0.75
0.50
0.25
0.00
0
5
10
15
20
Time
Number at risk
Low 1975 1268 399 23 0
0.431 <= Risk < 0.542 364 160 47 2 0
Risk >= 0.542 643 143 37 1 0

```
par(op)
```

### Training Report

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

Table 44: O/E Ratio

| est | lower | upper |
|---|---|---|
| 0.957 | 0.91 | 1.01 |

```
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**: *4206588*
- **Uncertain**: *2703838*
- **cstatCI**:

| mean.C Index | median | lower | upper |
|---|---|---|---|
| 0.68 | 0.68 | 0.667 | 0.694 |

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

Table 46: ROC AUC

| est | lower | upper |
|---|---|---|
| 0.695 | 0.677 | 0.714 |

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

Table 47: Sensitivity

| est | lower | upper |
|---|---|---|
| 0.327 | 0.303 | 0.351 |

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

Table 48: Specificity

| est | lower | upper |
|---|---|---|
| 0.9 | 0.883 | 0.915 |

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

Table 49: Probability Thresholds

| 90% | 80% |
|---|---|
| 0.542 | 0.431 |

```
pander::pander(t(rrAnalysisTrain$RR_atP),caption="Risk Ratio")
```

Table 50: Risk Ratio

| est | lower | upper |
|---|---|---|
| 1.77 | 1.66 | 1.88 |

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

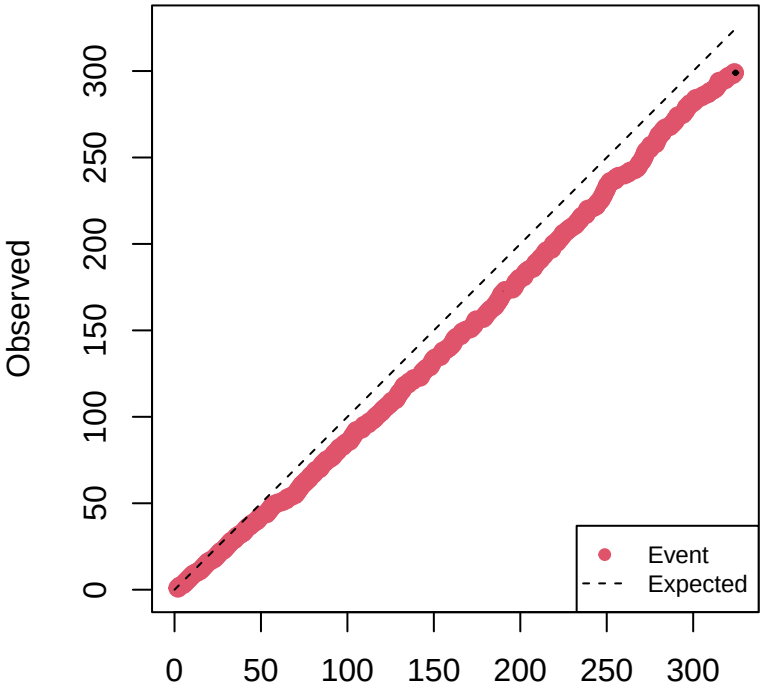
Table 51: Logrank test Chisq = 543.347175 on 2 degrees of freedom, p = 0.000000

| | N | Observed | Expected | (O-E)^2/E | (O-E)^2/V |
|---|---|---|---|---|---|
| **class=0** | 1975 | 804 | 1145 | 101.5 | 418.9 |
| **class=1** | 364 | 218 | 169 | 14.1 | 15.9 |
| **class=2** | 643 | 496 | 204 | 418.2 | 490.7 |

**Results on the validation set using Logistic model**

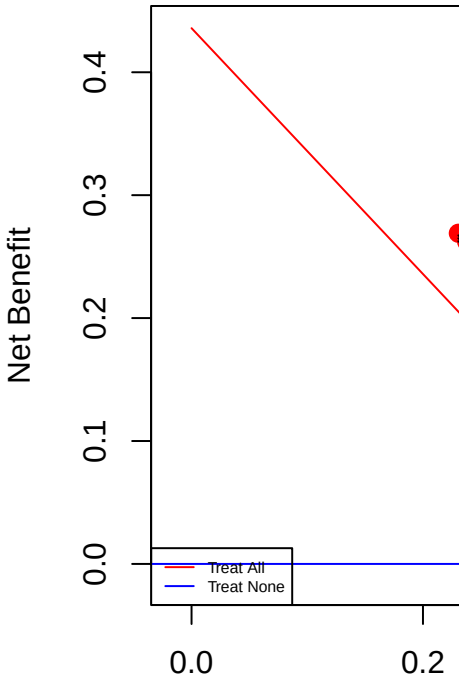
```
pre <- predict(mlog,dataBrestCancerTest)
rdata <- cbind(dataBrestCancerTest$status,pre)

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

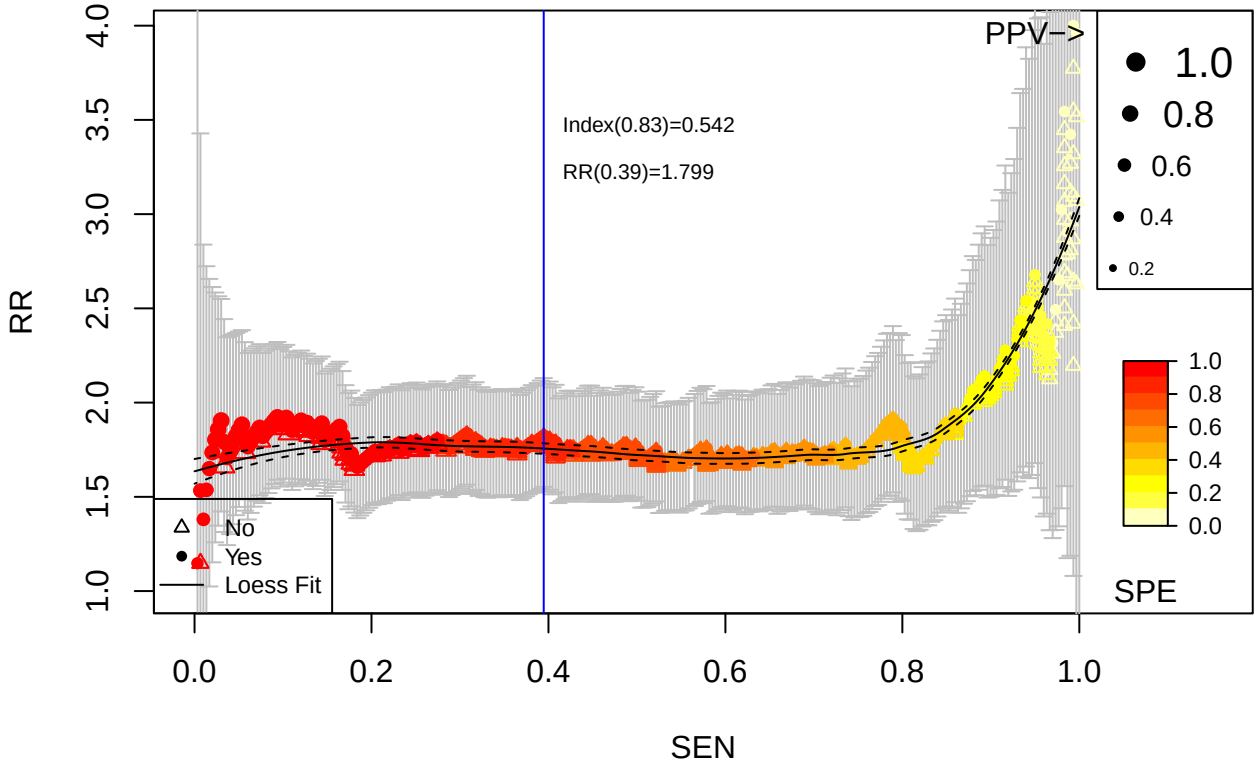


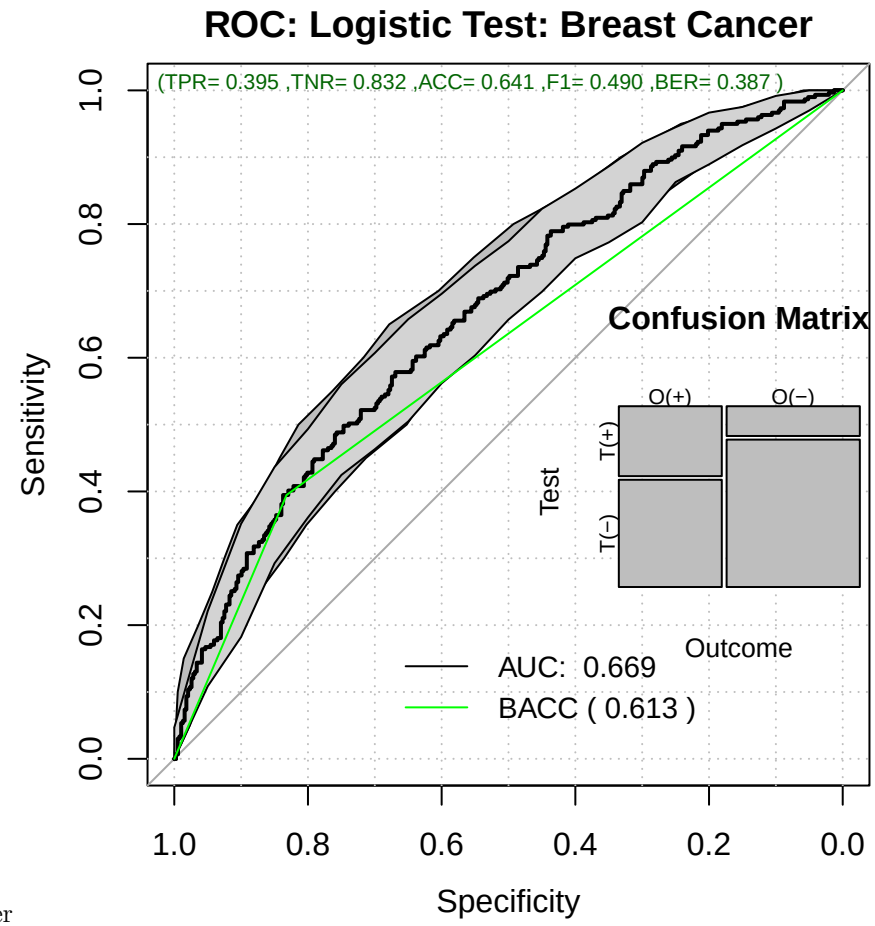

Cumulative Probability

## Decision Curv

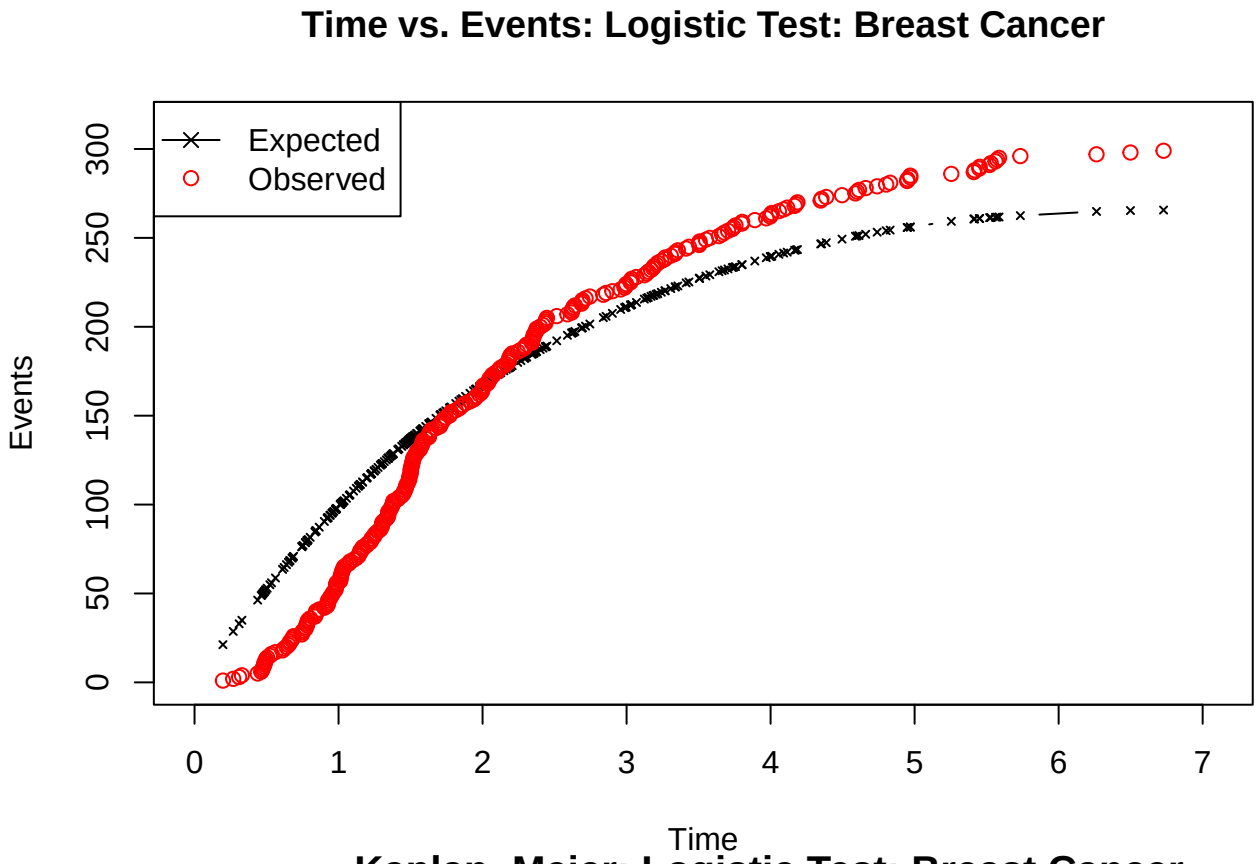


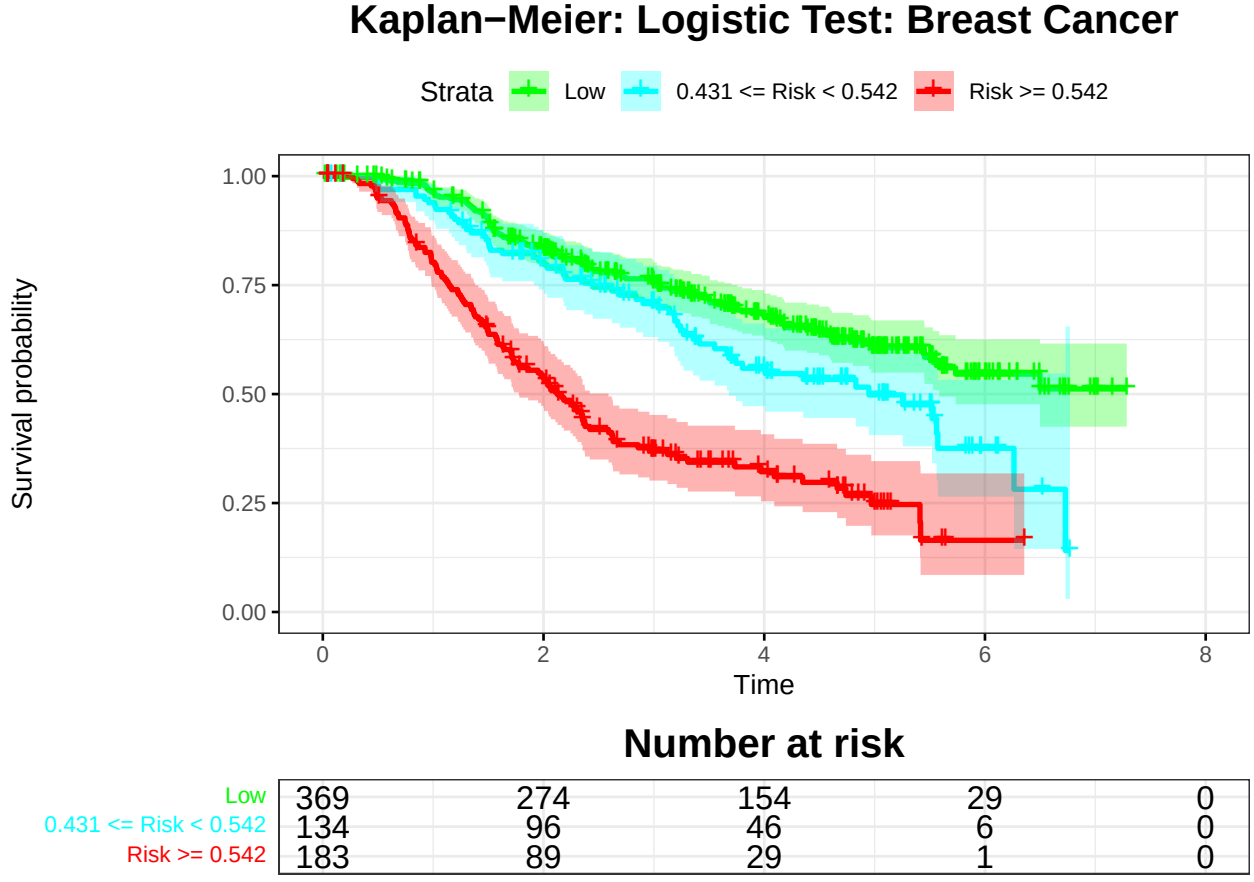

## Relative Risk: Logistic Test: Breast Cancer






ROC: Logistic Test: Breast Cancer


Time vs. Events: Logistic Test: Breast Cancer
Expected
Observed
Events
0
50
100
150
200
250
300
0
1
2
3
4
5
6
7
Time


Kaplan−Meier: Logistic Test: Breast Cancer
Strata
Low
0.431 <= Risk < 0.542
Risk >= 0.542
Survival probability
1.00
0.75
0.50
0.25
0.00
0
2
4
6
8
Time
Number at risk
Low 369 274 154 29 0
0.431 <= Risk < 0.542 134 96 46 6 0
Risk >= 0.542 183 89 29 1 0

```
par(op)
```

### Validation Report

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

Table 52: O/E Ratio

| est | lower | upper |
|---|---|---|
| 1.13 | 1 | 1.26 |

```
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 | 0.669 | 0.637 | 0.698 |

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

Table 54: ROC AUC

| est | lower | upper |
|---|---|---|
| 0.669 | 0.628 | 0.709 |

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

Table 55: Sensitivity

| est | lower | upper |
|---|---|---|
| 0.395 | 0.339 | 0.453 |

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

Table 56: Specificity

| est | lower | upper |
|---|---|---|
| 0.832 | 0.791 | 0.868 |

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

Table 57: Probability Thresholds

| 90% | 80% |
|---|---|
| 0.542 | 0.431 |

```
pander::pander(t(rrAnalysis$RR_atP),caption="Risk Ratio")
```

Table 58: Risk Ratio

| est | lower | upper |
|---|---|---|
| 1.8 | 1.54 | 2.11 |

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

Table 59: 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 |

## Logistic Model Poisson Calibration

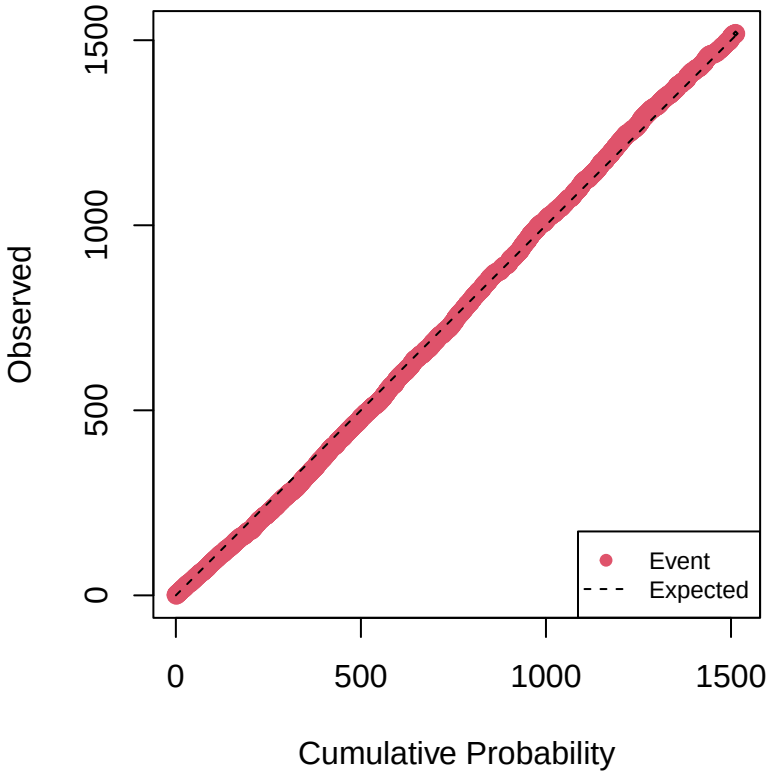
```
riskdata <- cbind(dataBrestCancerTrain$status,predict(mlog,dataBrestCancerTrain,type="prob"),dataBrestCa
calprob <- CalibrationProbPoissonRisk(riskdata)

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

| h0 | Gain | DeltaTime |
|---|---|---|
| 0.676 | 1.31 | 7.14 |

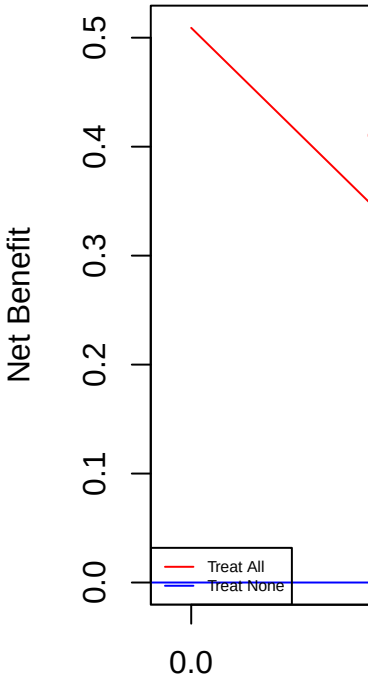
```
timeinterval <- calprob$timeInterval;
gain <- calprob$hazardGain

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

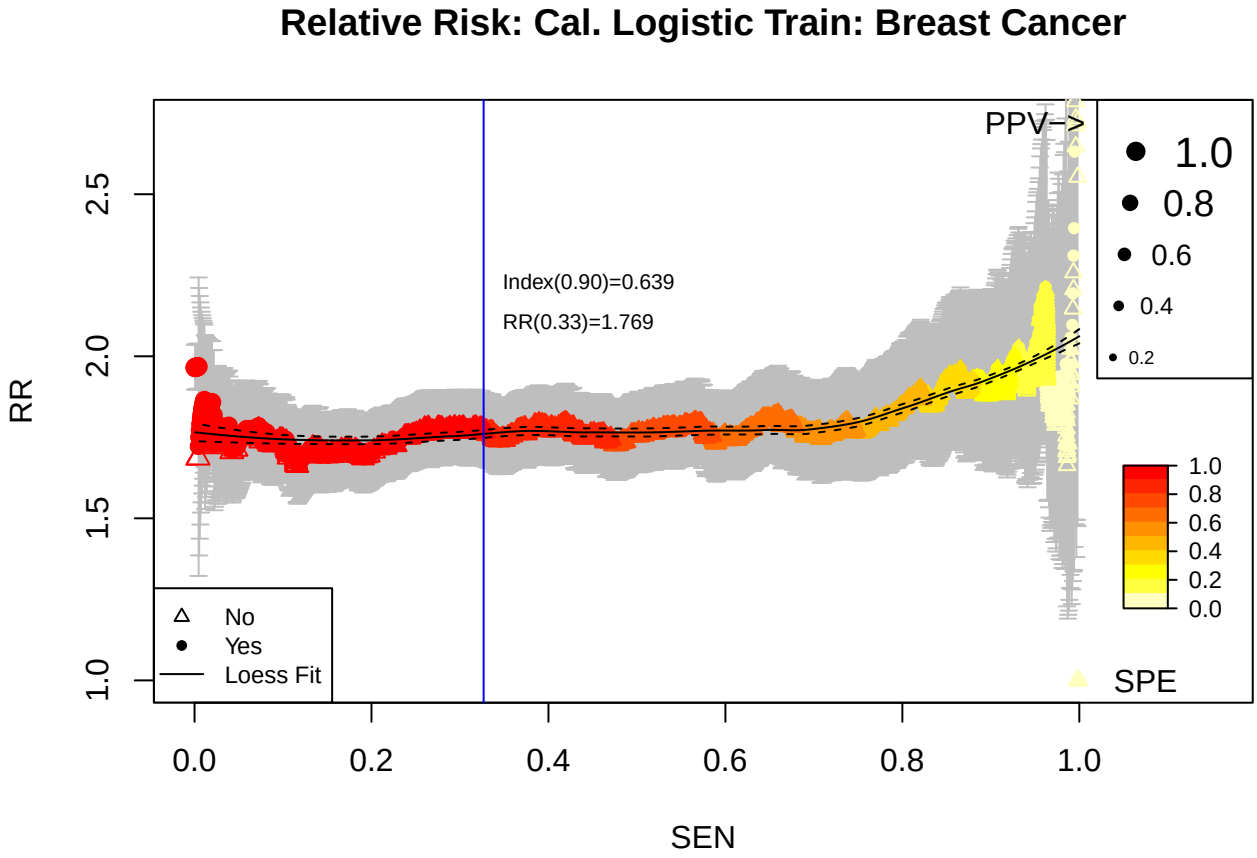
```
rrAnalysisTrain <- RRPlot(rdata,atProb=c(0.90,0.80),
                          timetoEvent=dataBrestCancerTrain$time,
                          title="Cal. Logistic Train: Breast Cancer",
                          ysurvlim=c(0.00,1.0),
                          riskTimeInterval=timeinterval)
```

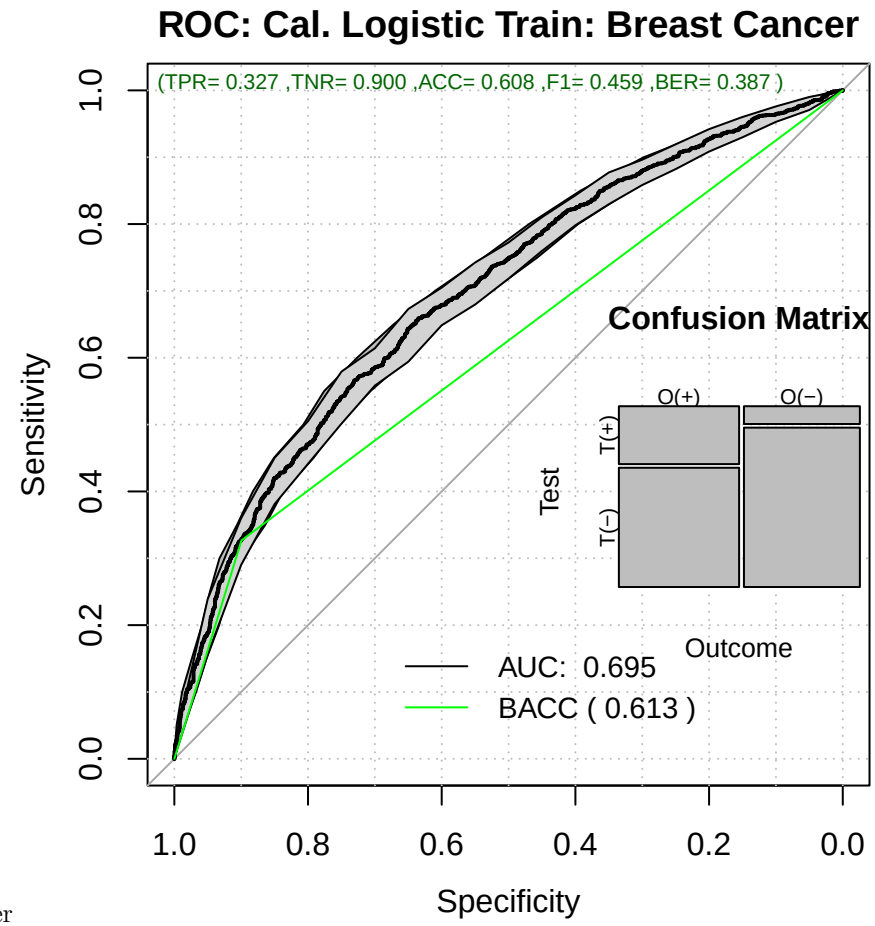
**Cumulative vs. Observed: Cal. Logistic Train: Breast Cancer**



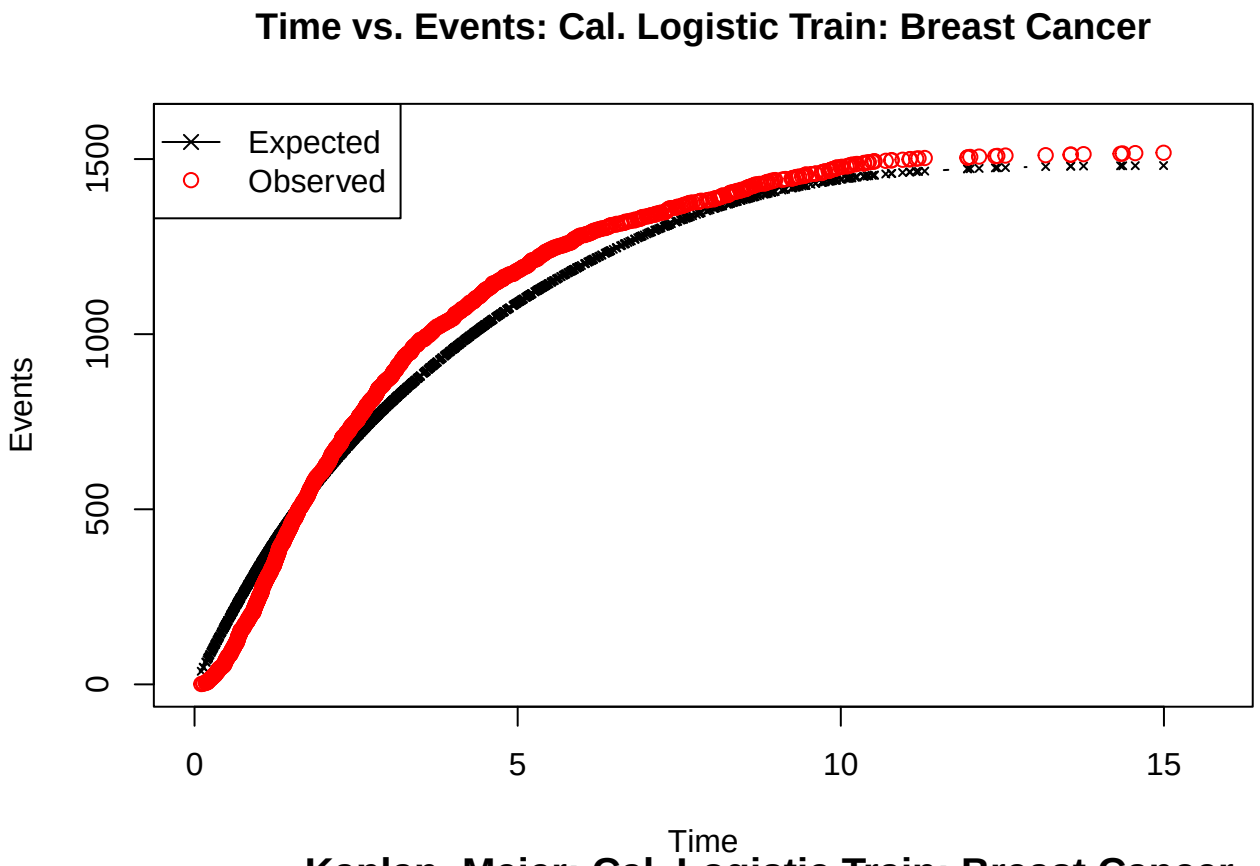

**Decision C**

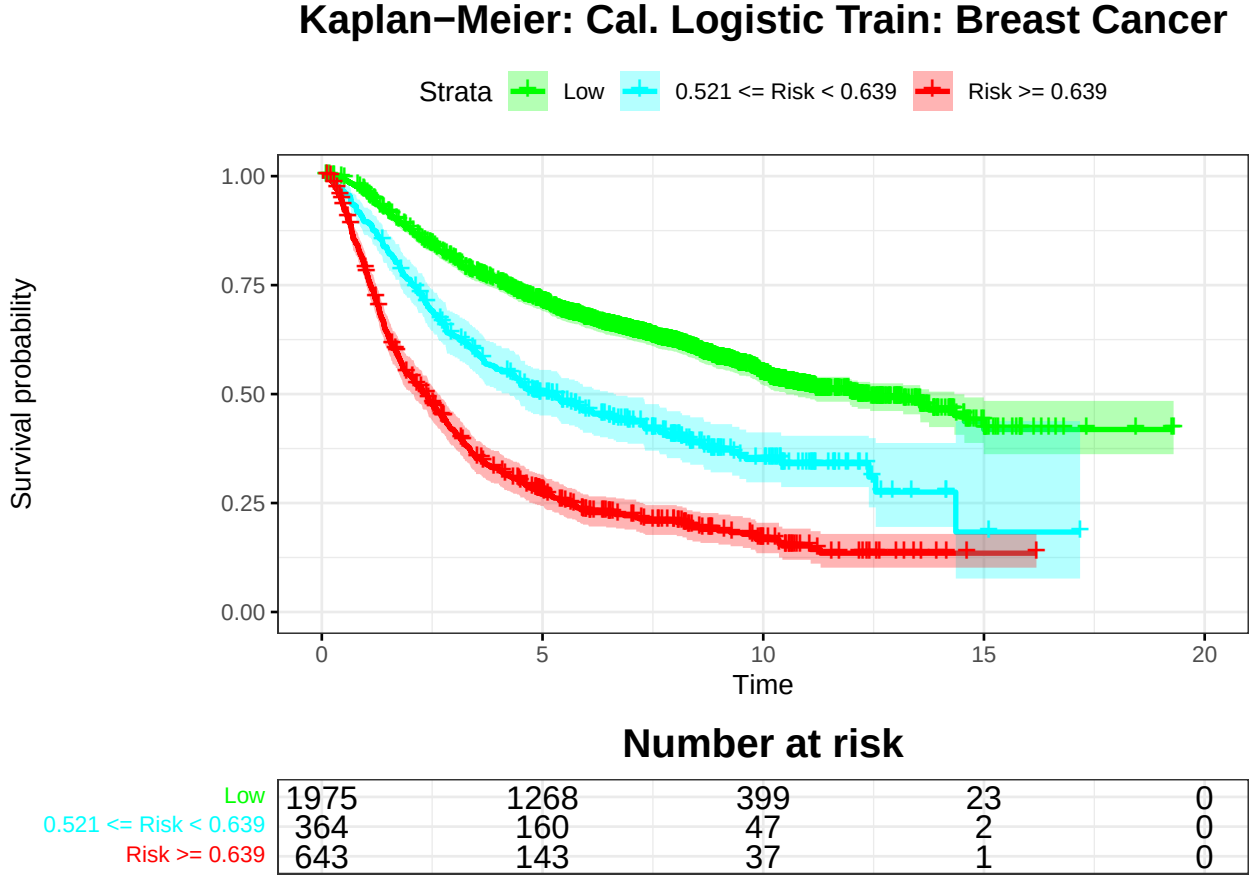



Relative Risk: Cal. Logistic Train: Breast Cancer
PPV- >
1.0
0.8
0.6
0.4
0.2
Index(0.90)=0.639
RR(0.33)=1.769
1.0
0.8
0.6
0.4
0.2
0.0
No
Yes
Loess Fit
SPE
RR
2.5
2.0
1.5
1.0
0.0
0.2
0.4
0.6
0.8
1.0
SEN




ROC: Cal. Logistic Train: Breast Cancer




## Number at risk

| | | | | | |
|---|---|---|---|---|---|
| Low | 1975 | 1268 | 399 | 23 | 0 |
| 0.521 <= Risk < 0.639 | 364 | 160 | 47 | 2 | 0 |
| Risk >= 0.639 | 643 | 143 | 37 | 1 | 0 |

```
par(op)
```

**Report of the calibrated logistic: training**

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

Table 61: O/E Ratio

| est | lower | upper |
|---|---|---|
| 1.02 | 0.974 | 1.08 |

```
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**: *4206588*
- **Uncertain**: *2703838*
- **cstatCI**:

| mean.C Index | median | lower | upper |
|---|---|---|---|
| 0.68 | 0.68 | 0.666 | 0.693 |

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

Table 63: ROC AUC

| est | lower | upper |
|---|---|---|
| 0.695 | 0.677 | 0.714 |

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

Table 64: Sensitivity

| est | lower | upper |
|---|---|---|
| 0.327 | 0.303 | 0.351 |

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

Table 65: Specificity

| est | lower | upper |
|---|---|---|
| 0.9 | 0.883 | 0.915 |

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

Table 66: Probability Thresholds

| 90% | 80% |
|---|---|
| 0.639 | 0.521 |

```
pander::pander(t(rrAnalysisTrain$RR_atP),caption="Risk Ratio")
```

Table 67: Risk Ratio

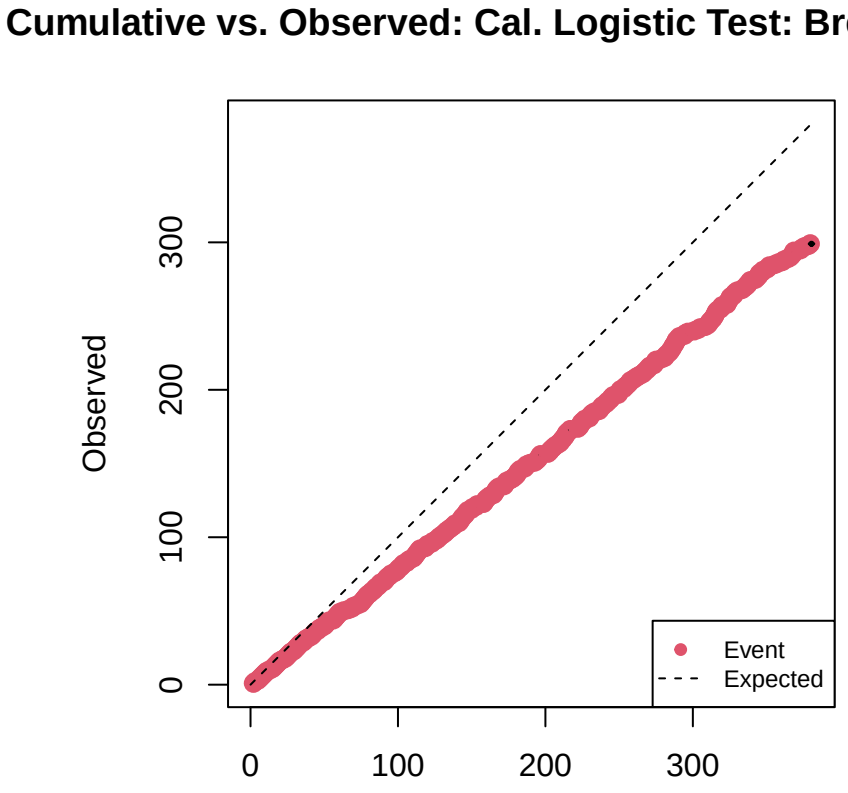
| est | lower | upper |
|---|---|---|
| 1.77 | 1.66 | 1.88 |

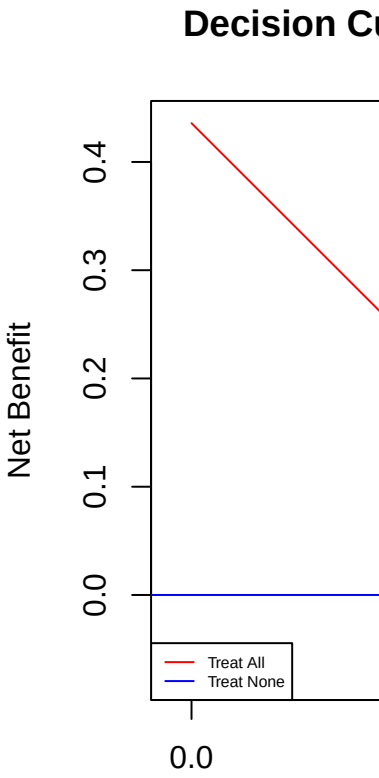
```
pander::pander(rrAnalysisTrain$sufdif,caption="Logrank test")
```

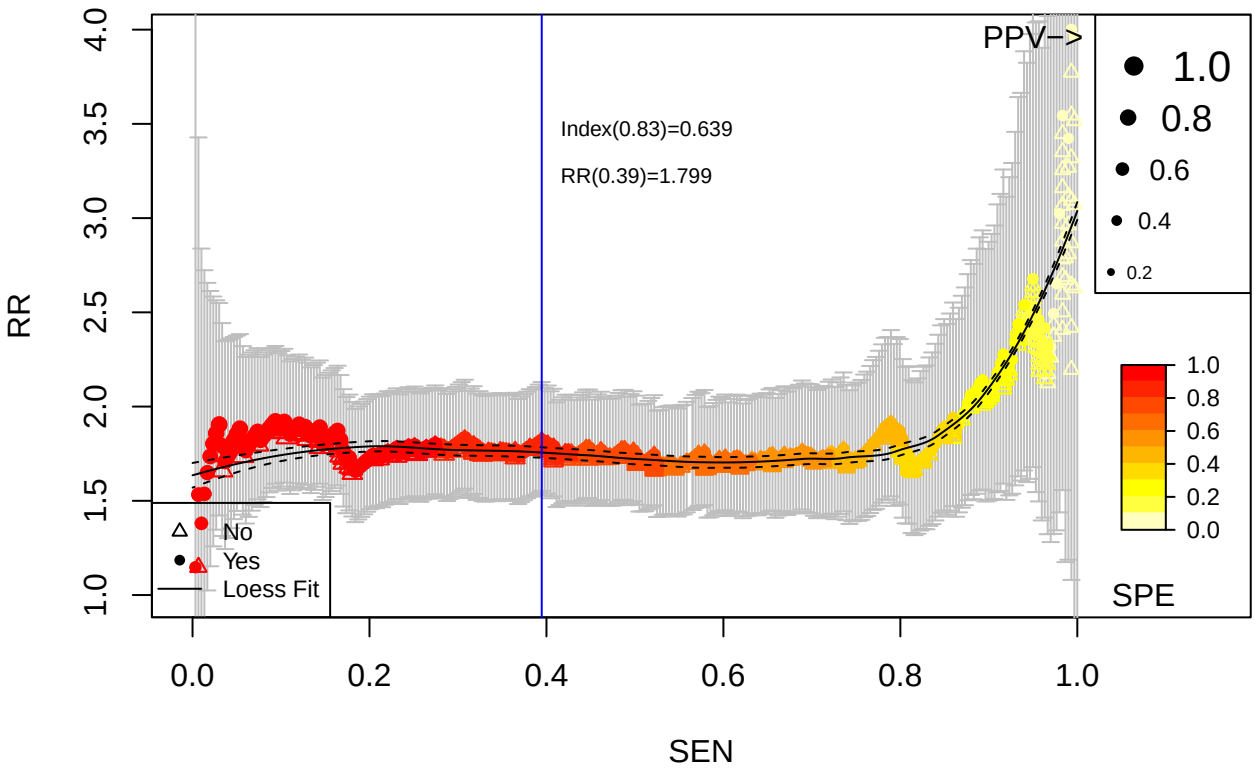
Table 68: Logrank test Chisq = 543.347175 on 2 degrees of freedom, p = 0.000000

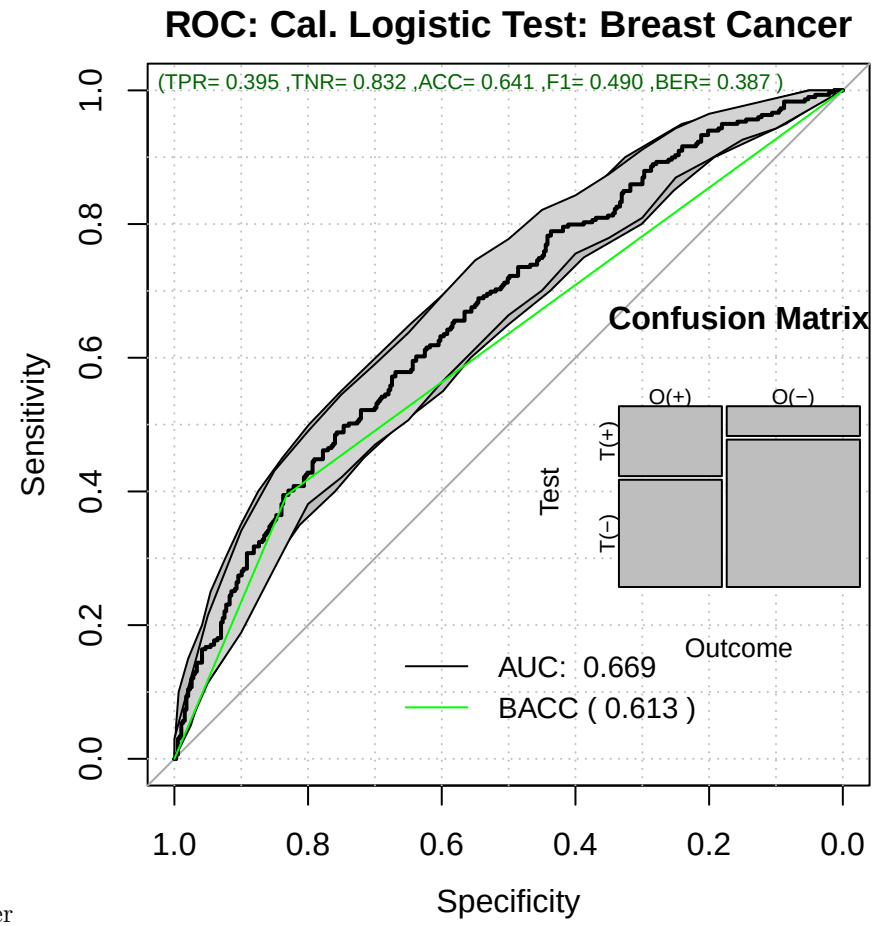
| | N | Observed | Expected | (O-E)^2/E | (O-E)^2/V |
|---|---|---|---|---|---|
| **class=0** | 1975 | 804 | 1145 | 101.5 | 418.9 |
| **class=1** | 364 | 218 | 169 | 14.1 | 15.9 |
| **class=2** | 643 | 496 | 204 | 418.2 | 490.7 |

```
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)
```

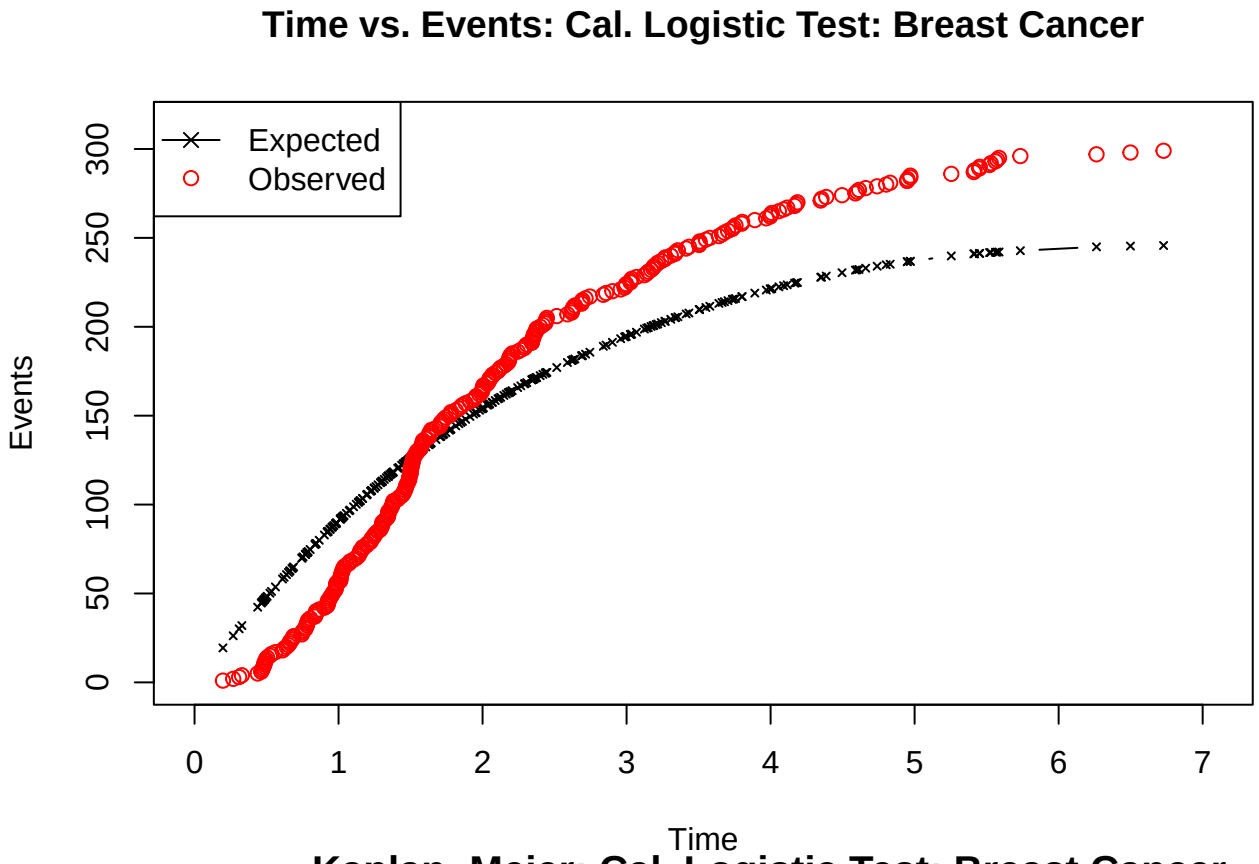

Cumulative vs. Observed: Cal. Logistic Test: Breast Cancer
Observed
0
100
200
300
Event
Expected
Cumulative Probability

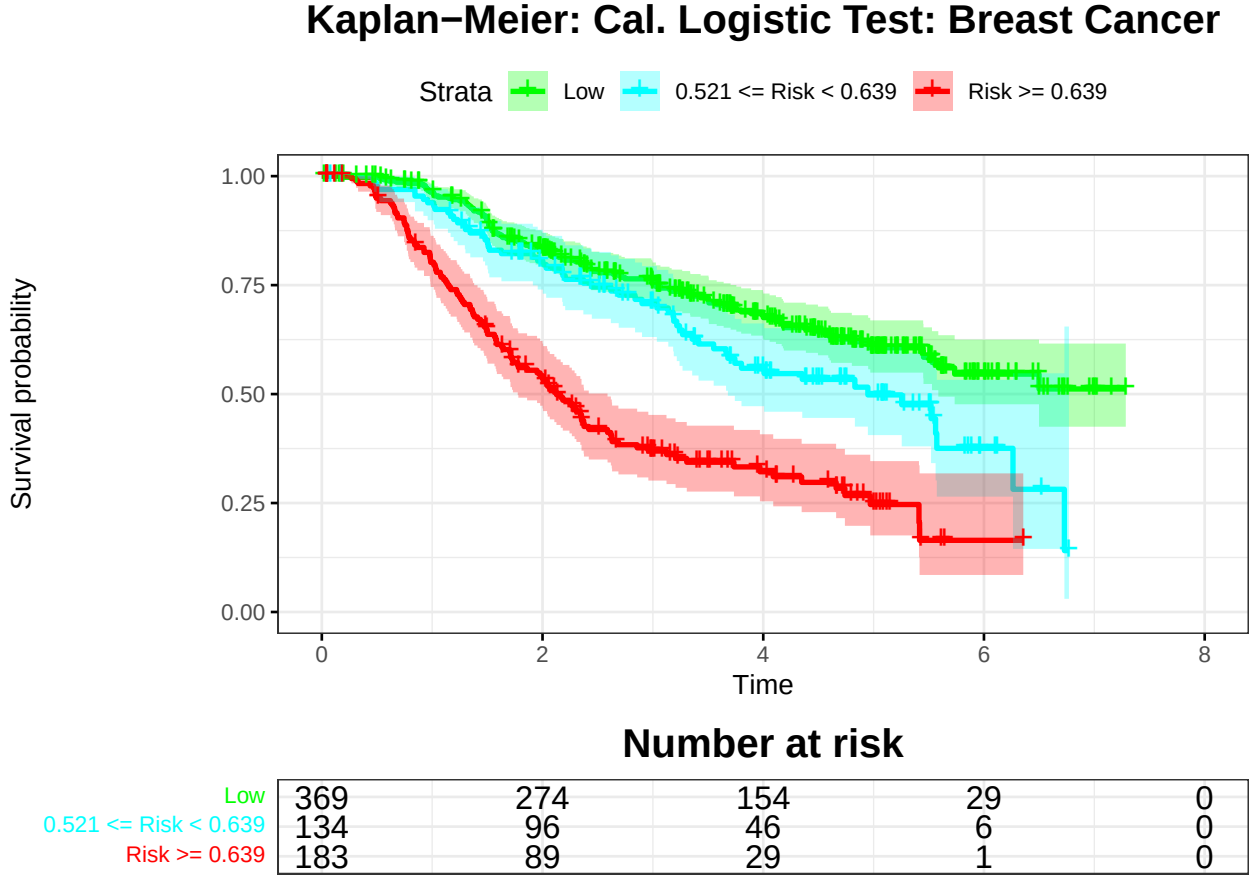

Decision Cu
Net Benefit
0.0
0.1
0.2
0.3
0.4
Treat All
Treat None
0.0


Relative Risk: Cal. Logistic Test: Breast Cancer
RR
1.0
1.5
2.0
2.5
3.0
3.5
4.0
PPV−>
Index(0.83)=0.639
RR(0.39)=1.799
1.0
0.8
0.6
0.4
0.2
1.0
0.8
0.6
0.4
0.2
0.0
SPE
No
Yes
Loess Fit
0.0
0.2
0.4
0.6
0.8
1.0
SEN




ROC: Cal. Logistic Test: Breast Cancer




## Number at risk

| | | | | | |
|---|---|---|---|---|---|
| Low | 369 | 274 | 154 | 29 | 0 |
| 0.521 <= Risk < 0.639 | 134 | 96 | 46 | 6 | 0 |
| Risk >= 0.639 | 183 | 89 | 29 | 1 | 0 |

```
par(op)
```

**Report of the calibrated validation**

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

Table 69: O/E Ratio

| est | lower | upper |
|---|---|---|
| 1.22 | 1.08 | 1.36 |

```
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 | 0.638 | 0.699 |

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

Table 71: ROC AUC

| est | lower | upper |
|---|---|---|
| 0.669 | 0.628 | 0.709 |

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

Table 72: Sensitivity

| est | lower | upper |
|---|---|---|
| 0.395 | 0.339 | 0.453 |

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

Table 73: Specificity

| est | lower | upper |
|---|---|---|
| 0.832 | 0.791 | 0.868 |

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

Table 74: Probability Thresholds

| 90% | 80% |
|---|---|
| 0.639 | 0.521 |

```
pander::pander(t(rrAnalysisTestLogistic$RR_atP),caption="Risk Ratio")
```

Table 75: Risk Ratio

| est | lower | upper |
|---|---|---|
| 1.8 | 1.54 | 2.11 |

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

Table 76: 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 |

## Comparing the COX and Logistic Models on the Independent Data

```
pander::pander(t(rrCoxTestAnalysis$OAcum95ci))
```

| mean | 50% | 2.5% | 97.5% |
|---|---|---|---|
| 0.841 | 0.841 | 0.839 | 0.842 |

```
pander::pander(t(rrAnalysisTestLogistic$OAcum95ci))
```

| mean | 50% | 2.5% | 97.5% |
|---|---|---|---|
| 0.791 | 0.791 | 0.791 | 0.792 |

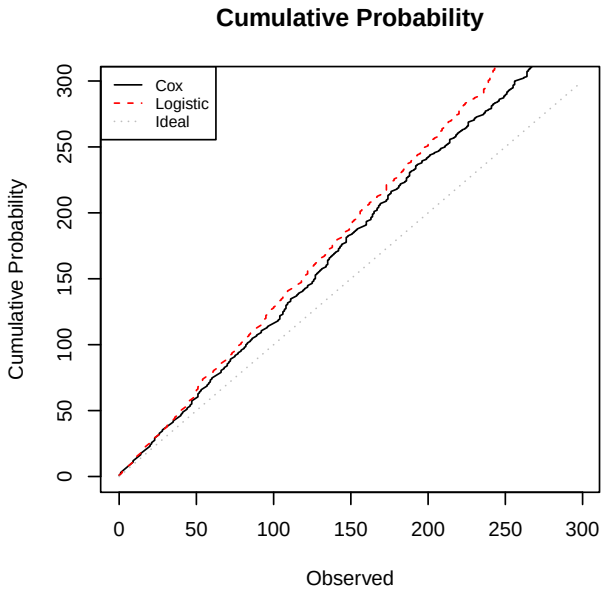
```
pander::pander(t(rrCoxTestAnalysis$OE95ci))
```

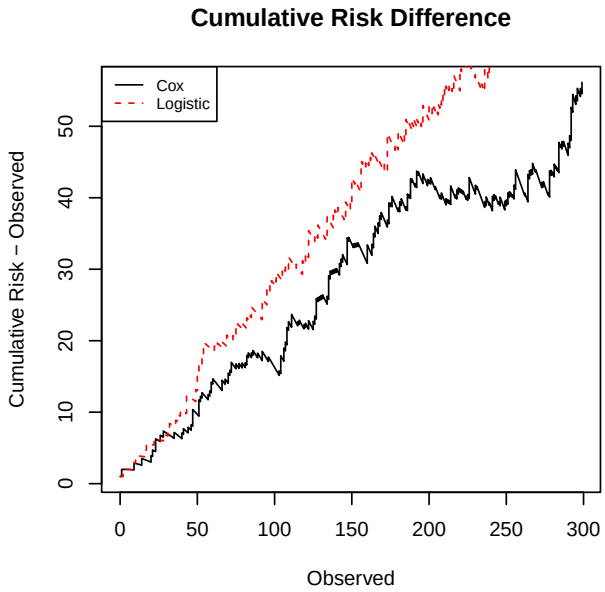
| mean | 50% | 2.5% | 97.5% |
|---|---|---|---|
| 1.07 | 1.07 | 1.04 | 1.1 |

```
pander::pander(t(rrAnalysisTestLogistic$OE95ci))
```

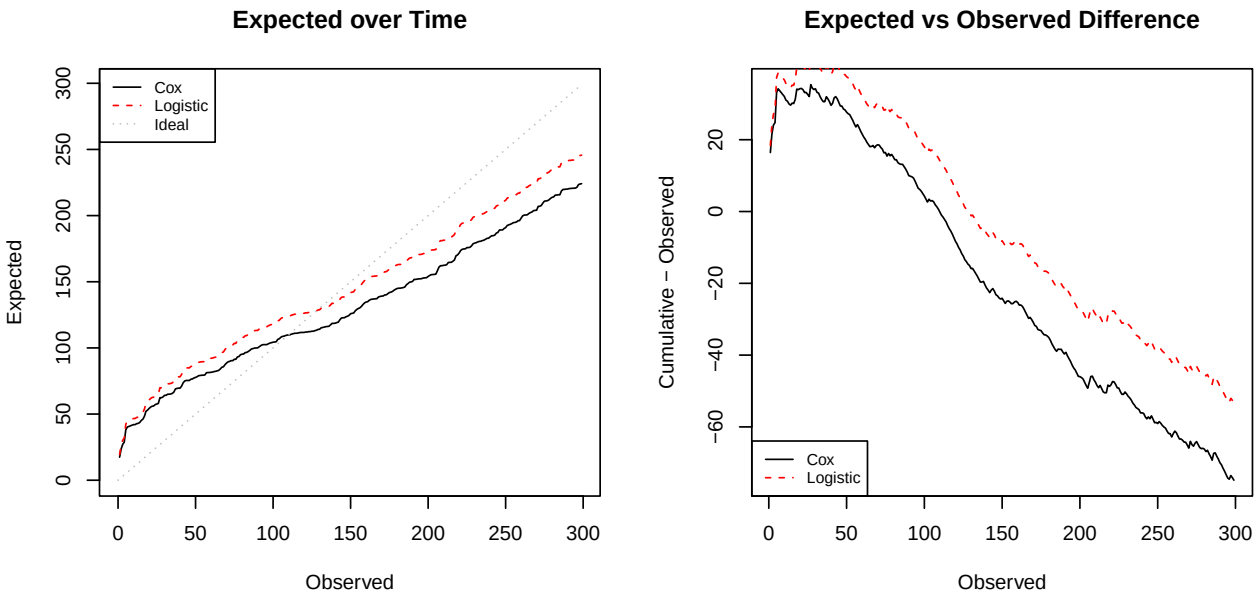
| mean | 50% | 2.5% | 97.5% |
|---|---|---|---|
| 0.955 | 0.955 | 0.927 | 0.985 |

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

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

plot(rrCoxTestAnalysis$CumulativeOvs,type="l",lty=1,
     main="Cumulative Probability",
     xlab="Observed",
     ylab="Cumulative Probability",
     ylim=c(0,maxobs),
     xlim=c(0,maxobs))
lines(rrAnalysisTestLogistic$CumulativeOvs,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
)
```


Expected over Time
Cox
Logistic
Ideal
Expected
Observed
0
50
100
150
200
250
300
Expected vs Observed Difference
Cumulative − Observed
20
0
−20
−40
−60

```
par(op)
```