Finding Simple Classification Rules in Risk Analysis

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The Women's Health and Aging Study

[With Karen Bandeen-Roche]

The Women's Health and Aging Study (WHAS) began in 1992 to study the causes and the course of disability in moderately to severely disabled older women living in the community.

The WHAS is a population-based longitudinal study of women with at least mild disability, 65 years of age or older, living at home in eastern Baltimore city or county.

There is evidence that disability results from chronic diseases, and that interactions between diseases (comorbidities) are of importance in causing disability.

In this presentation we are concerned about relating chronic diseases and their interactions to death.

The Women's Health and Aging Study

Study subjects:

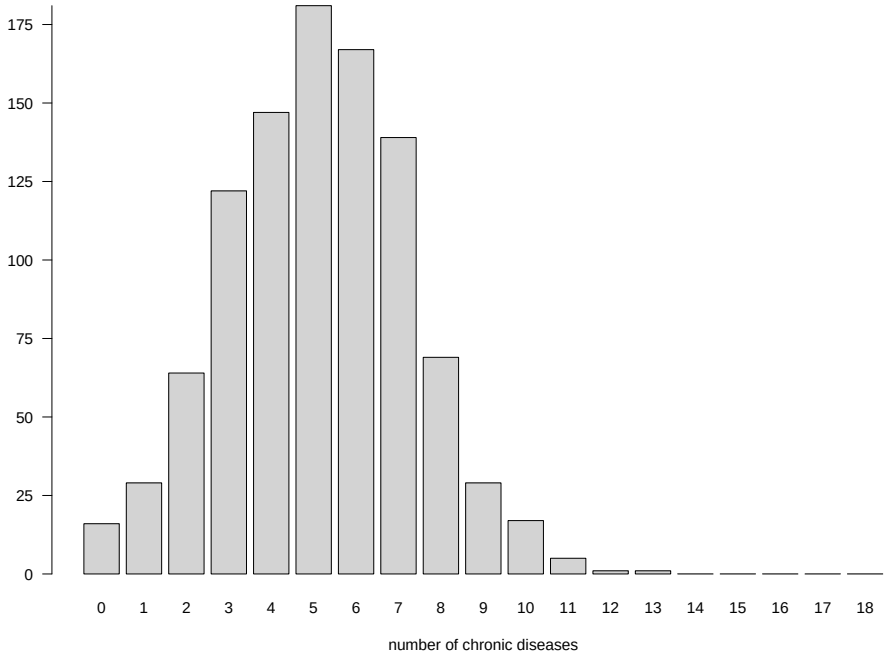
- 32538 women were identified by searching medicare enrollment files,
- 6521 women were sampled (age-stratified),
- 5316 women were alive and living at home,
- 4137 women participated in the home-based screening,
- 1409 women were eligible,
- 1002 women agreed to participate and provided written informed consent.

The major chronic diseases at baseline were ascertained by using complex algorithms. Follow-up evaluations were conducted every 6 months for 3 years.

The Women's Health and Aging Study

angina	heart pain
cancer	cancer
chf	congestion heart failure
diabetes	diabetes
disc	degenerative disc disease
hf	hip fracture
mi	myocardial infarction
oatot	osteo-arthritis at hand, knee or hip
oahand	osteo-arthritis at hand
oahip	osteo-arthritis at knee
oaknee	osteo-arthritis at hip
osteo	osteoporosis
pad	peripheral arterial disease
parkin	parkinson's disease
pulmonary	pulmonary disease
ra	rheumatoid arthritis
stenosis	spical stenosis
stroke	stroke

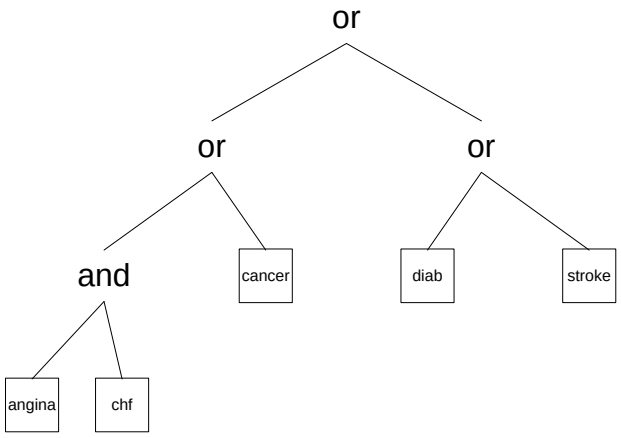
The Women's Health and Aging Study



The Women's Health and Aging Study

$$p = \Pr(\text{death in round } j \mid \text{survival to round } j\text{-}1, X, \text{age})$$

$$\text{logit}(p) = -9.01 + 0.06 \cdot \text{age} + 1.07 \cdot L(X)$$



Logic Regression

[With Charles Kooperberg and Michael LeBlanc]

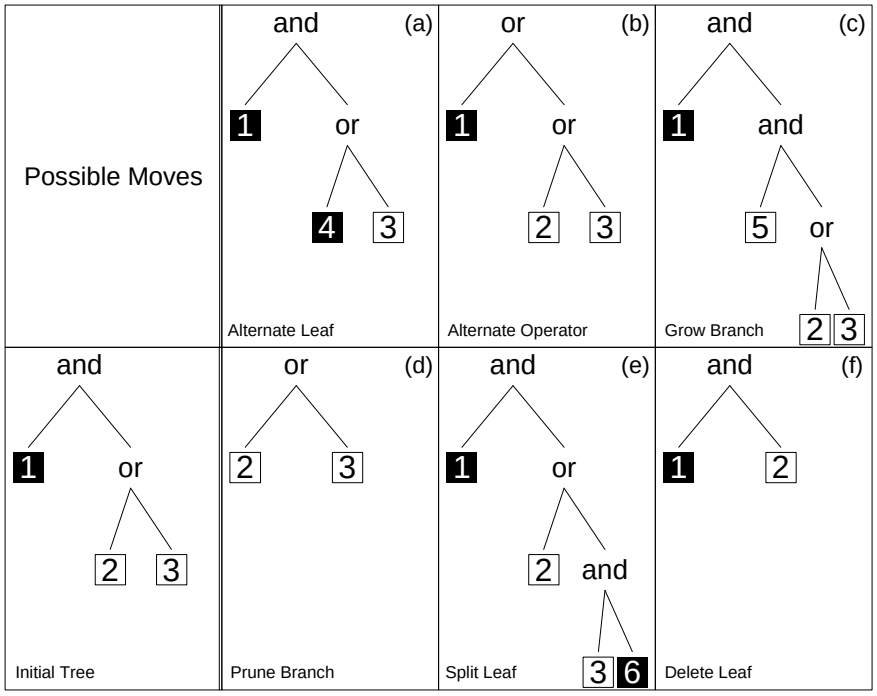
$X_1, \ldots, X_k$ are 0/1 (False/True) predictors.

Y is a response variable.

Fit a model $g(E(Y)) = b_0 + \sum_{j=1}^{t} b_j \cdot L_j$, where L_j is a Boolean combination of the covariates, e.g. $L_j = (X_1 \vee X_2) \wedge X_4^c$.

Determine the logic terms L_j and estimate the b_j simultaneously.

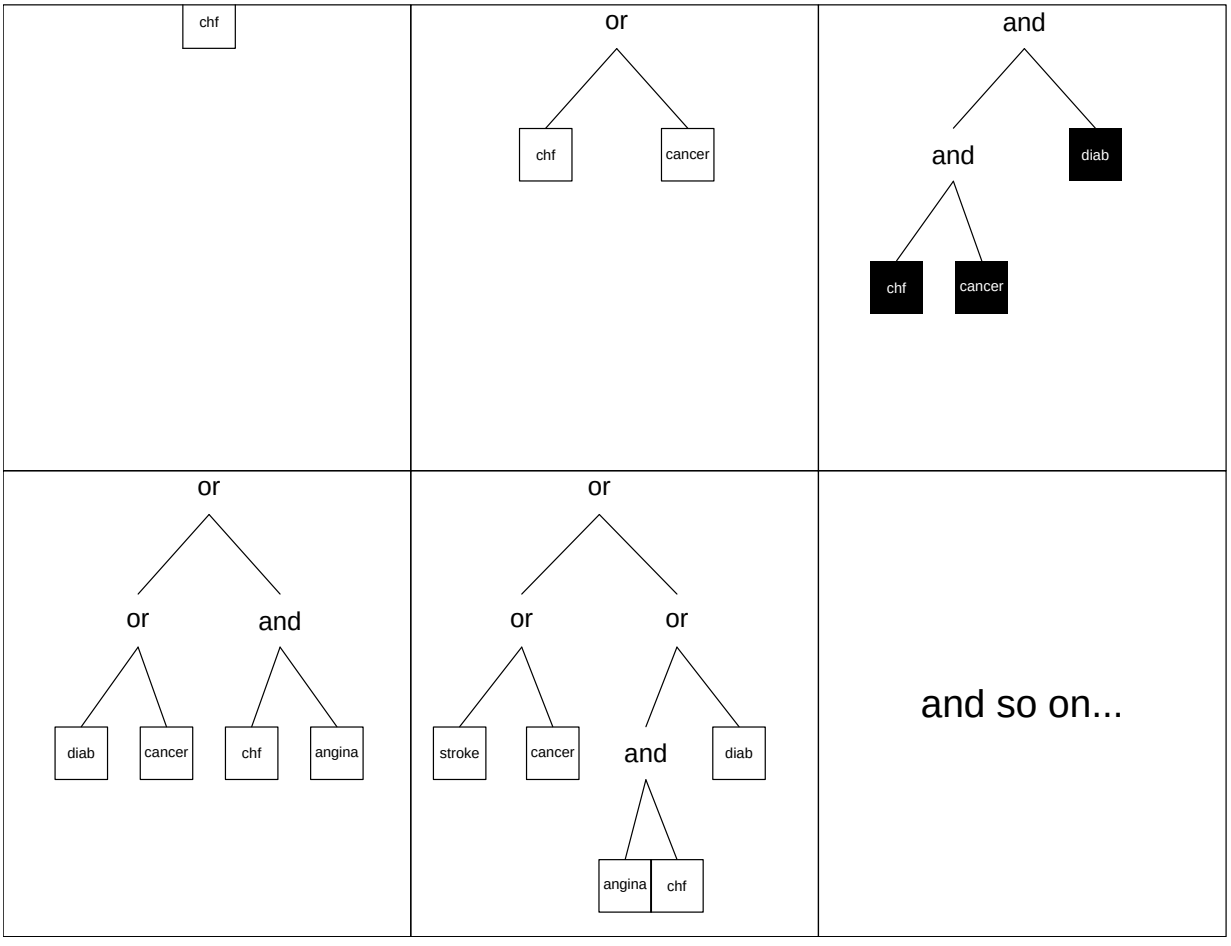
The Move Set for Logic Regression

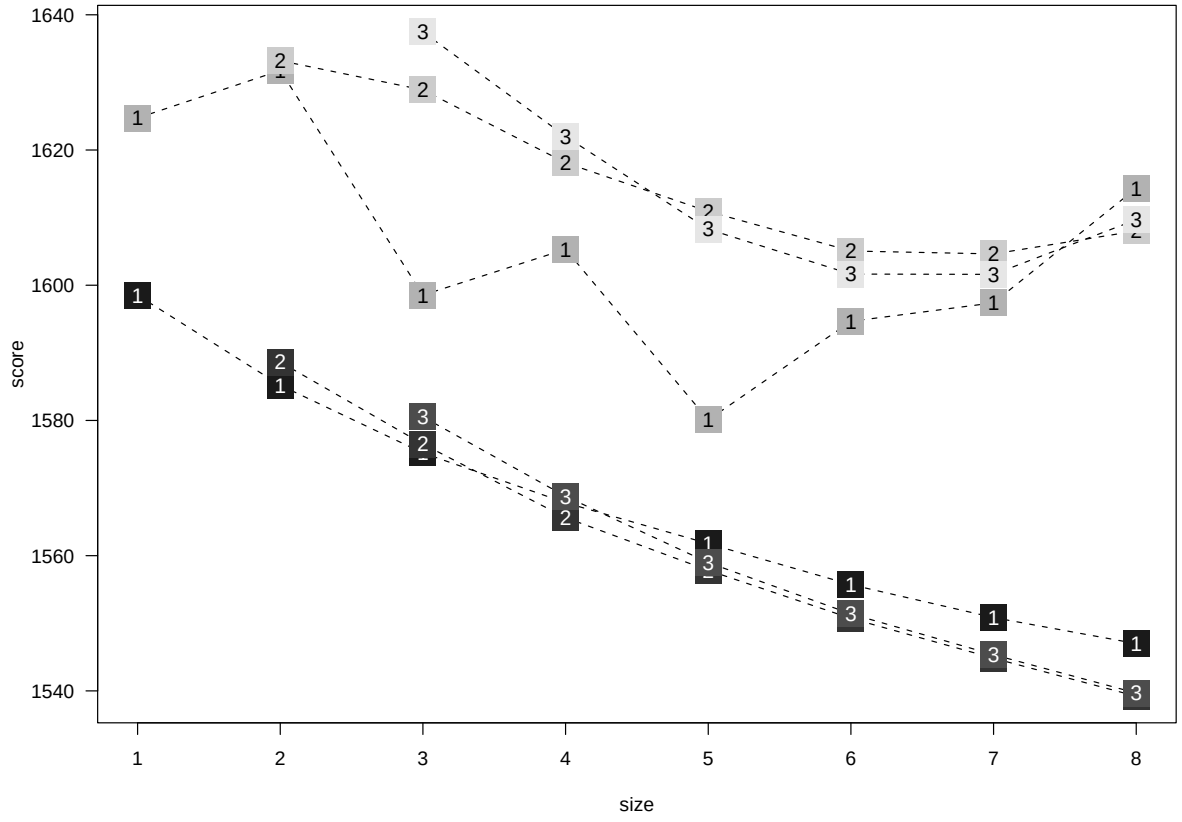


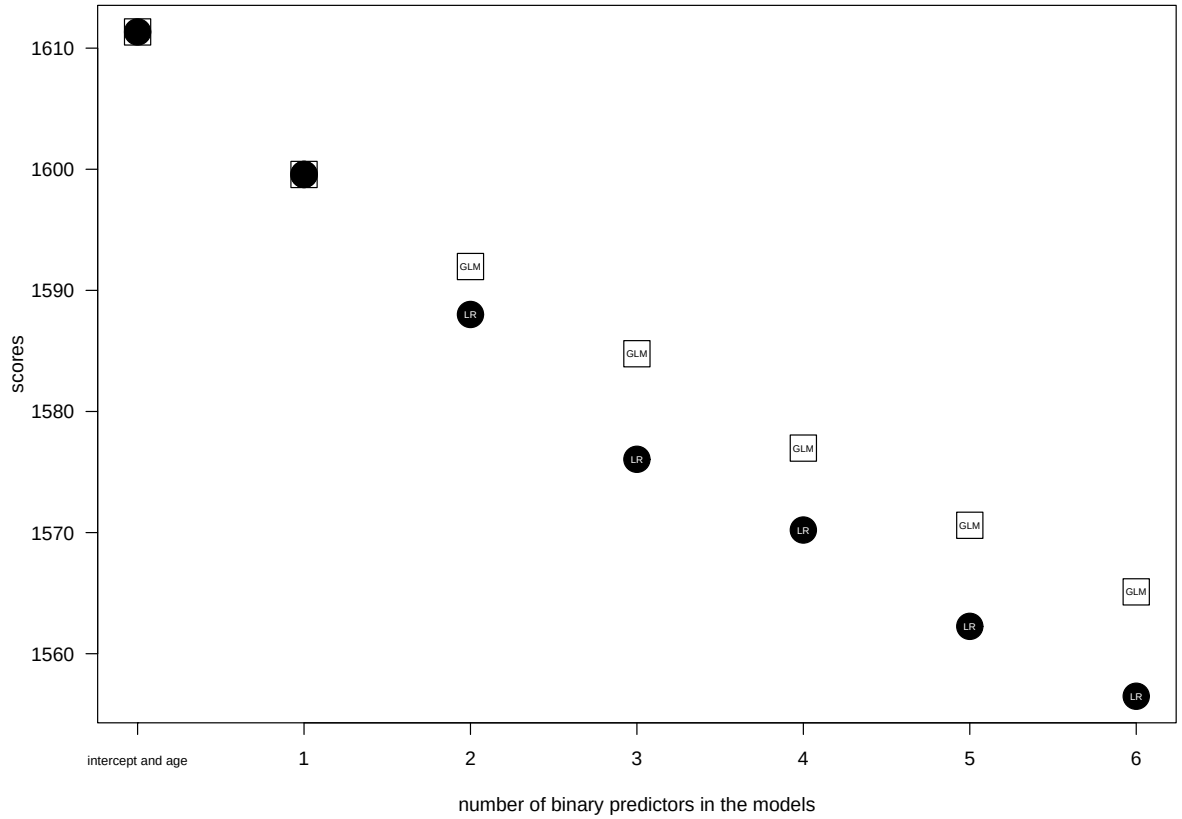
Simulated Annealing for Logic Regression

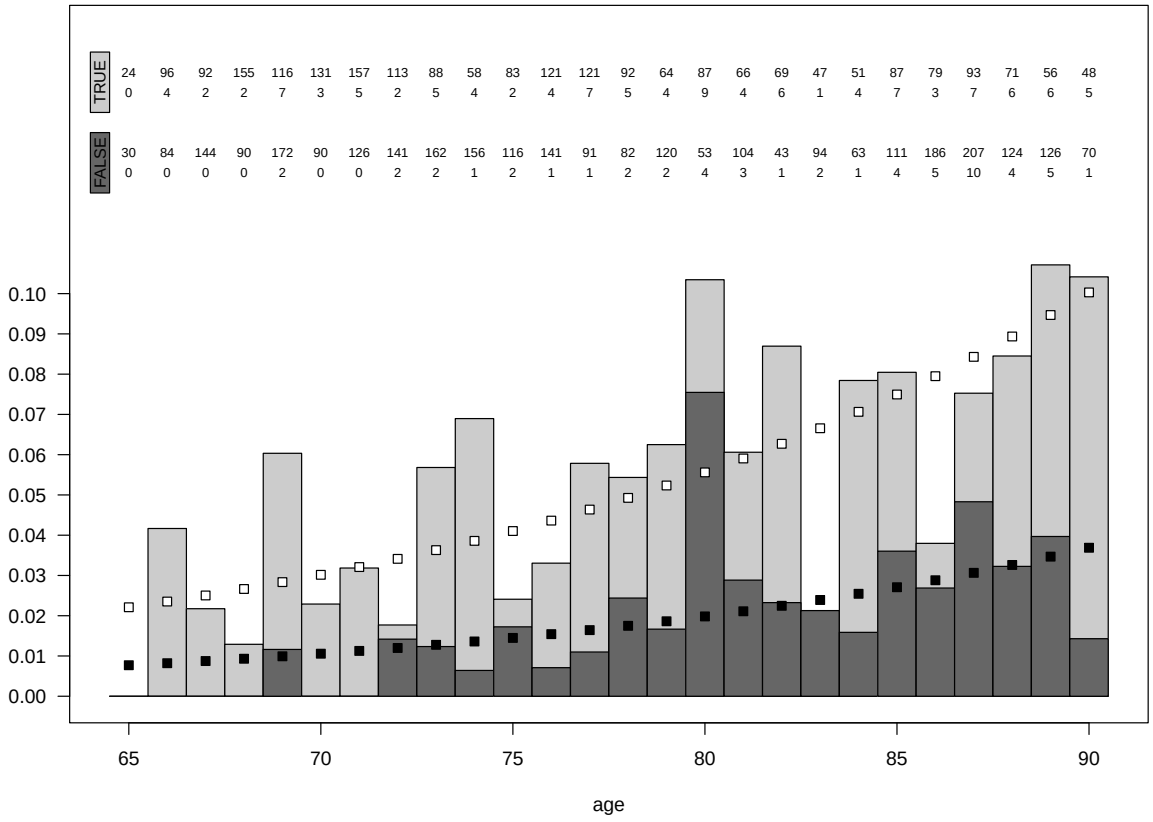
We try to fit the model $g(E(Y)) = b_0 + \sum_{j=1}^{t} b_j \cdot L_j$.

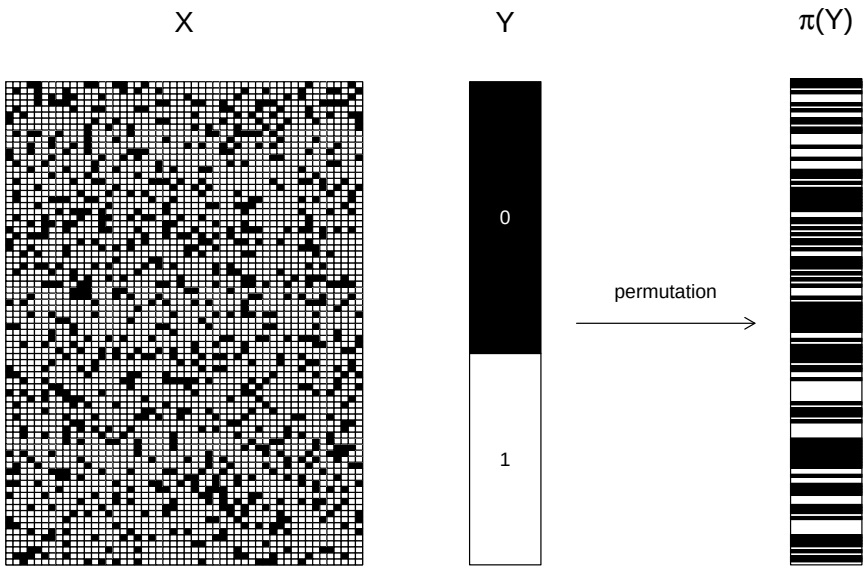
- Select a scoring function (RSS, log-likelihood, . . .).
- Pick the maximum number of Logic Trees.
- Pick the maximum number of leaves in a tree.
- Initialize the model with $L_j = 0$ for all j.
- Carry out the Simulated Annealing Algorithm:
  - Propose a move.
  - Accept or reject the move, depending on the scores and the temperature.

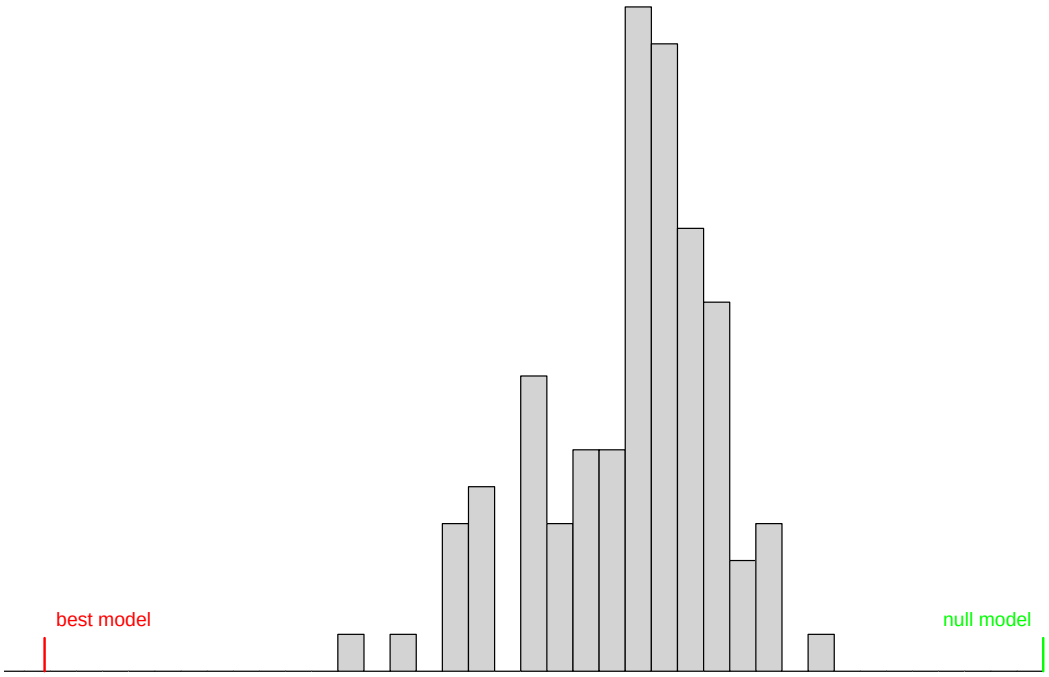


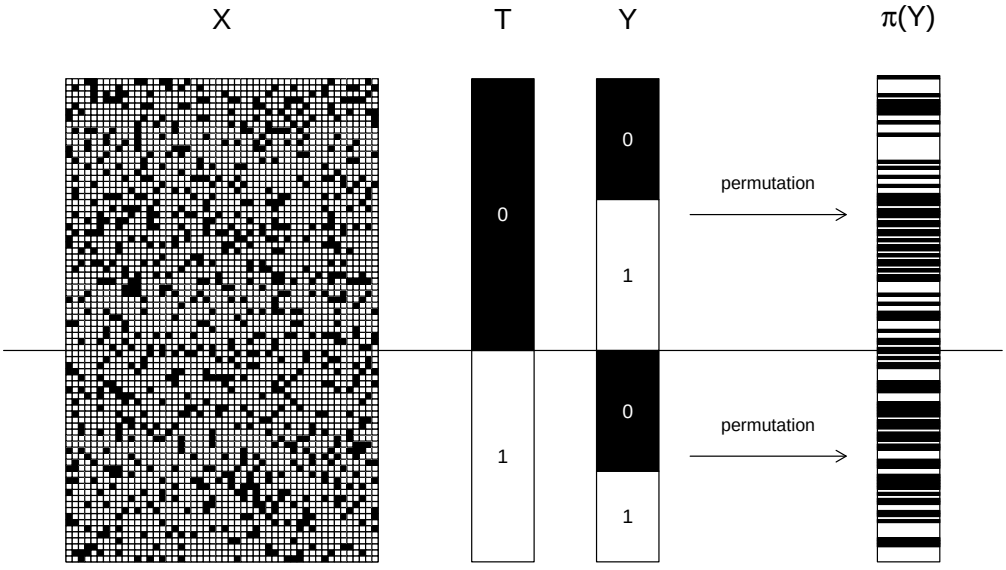

score
size
1640
1620
1600
1580
1560
1540
1
2
3
4
5
6
7
8

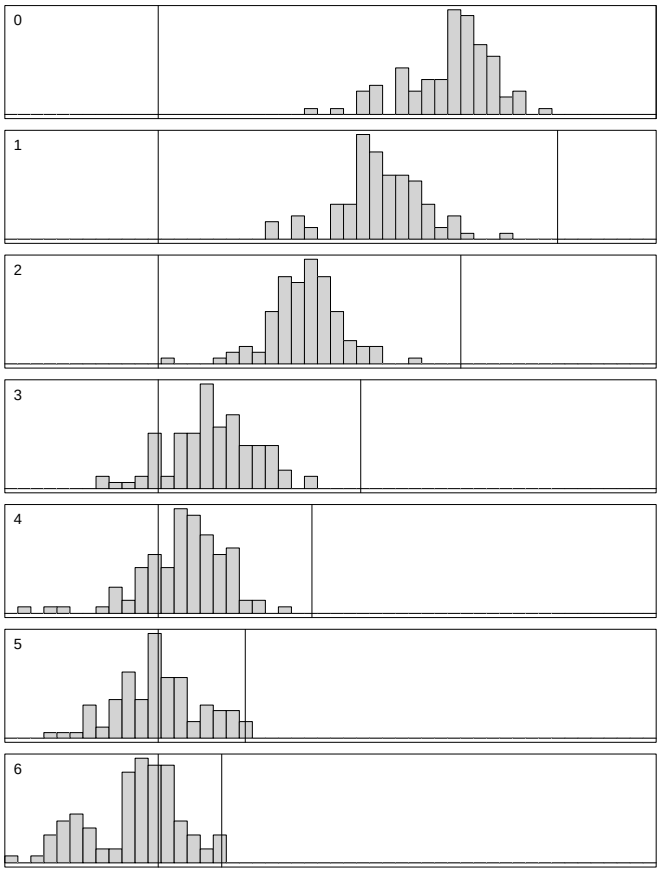

scores
number of binary predictors in the models
intercept and age
1610
1600
1590
1580
1570
1560
1
2
3
4
5
6
GLM
LR


TRUE
24 96 92 155 116 131 157 113 88 58 83 121 121 92 64 87 66 69 47 51 87 79 93 71 56 48
0 4 2 2 7 3 5 2 5 4 2 4 7 5 4 9 4 6 1 4 7 3 7 6 6 5
FALSE
30 84 144 90 172 90 126 141 162 156 116 141 91 82 120 53 104 43 94 63 111 186 207 124 126 70
0 0 0 0 2 0 0 2 2 1 2 1 1 2 2 4 3 1 2 1 4 5 10 4 5 1
0.10
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
65
70
75
80
85
90
age


X
Y
π(Y)
0
1
permutation


best model
null model


X
T
Y
π(Y)
0
1
0
1
permutation
permutation



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Software and manuscripts available at: http://biostat.jhsph.edu/∼iruczins/