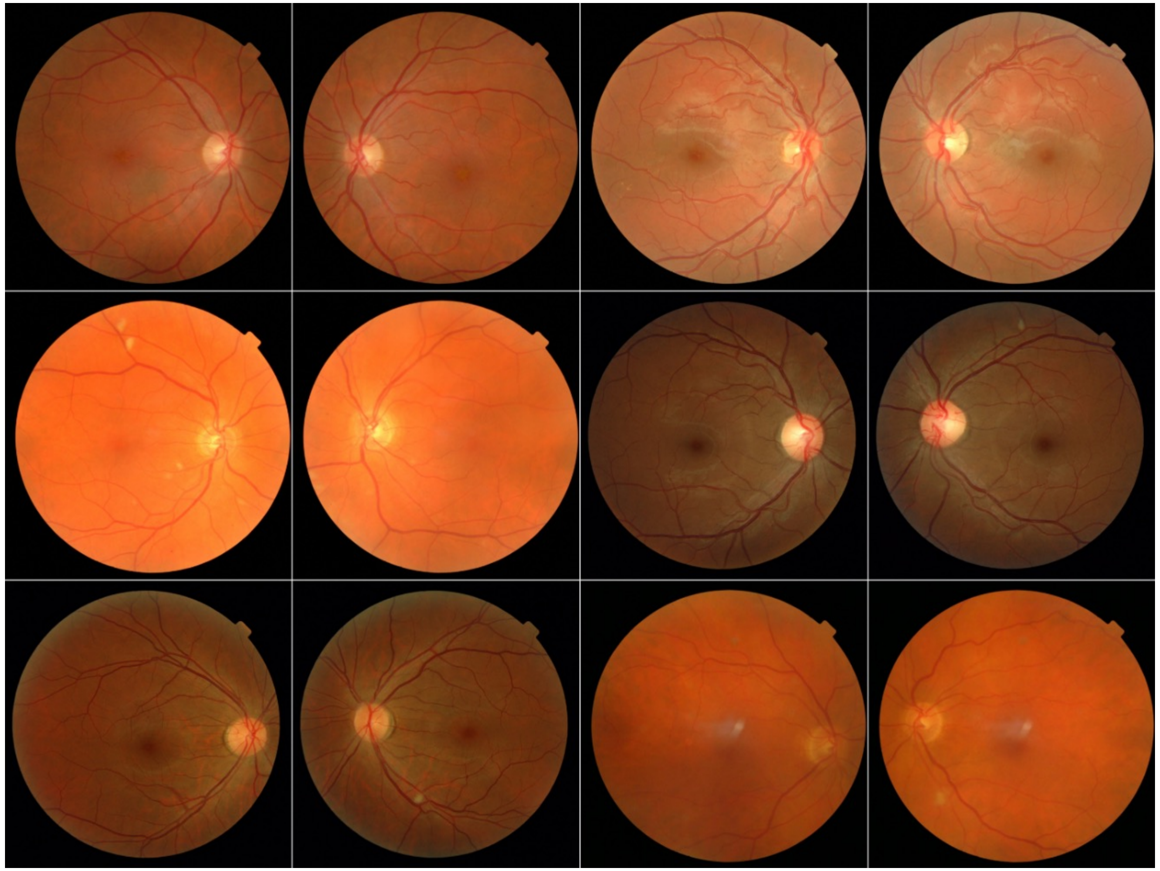
What is a Predictive Model?

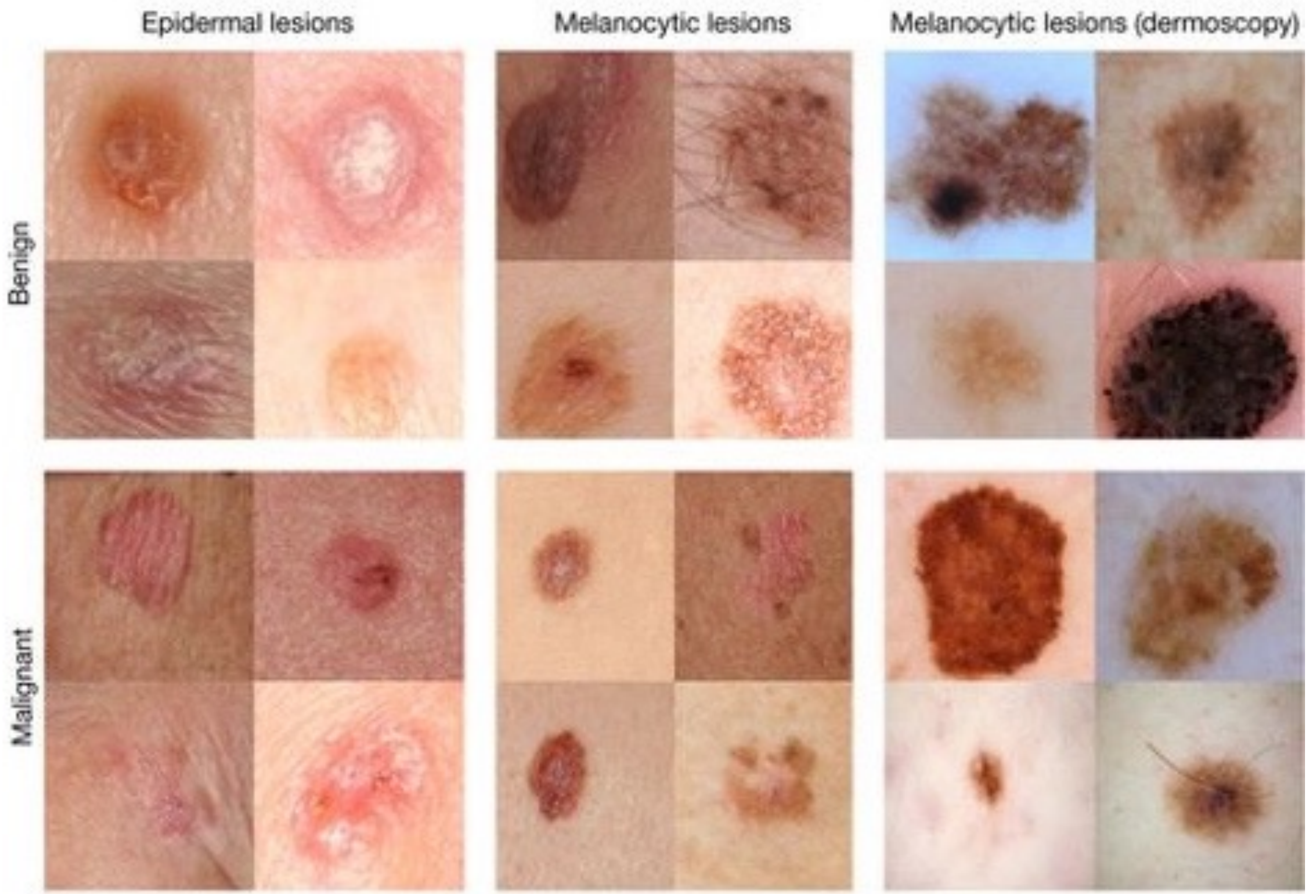
Matthew Engelhard

Medical Image Analysis with ConvNets



Improved Automated Detection of Diabetic Retinopathy

Invest. Ophthalmol. Vis. Sci.. 2016;57(13):5200-5206. doi:10.1167/iovs.16-19964

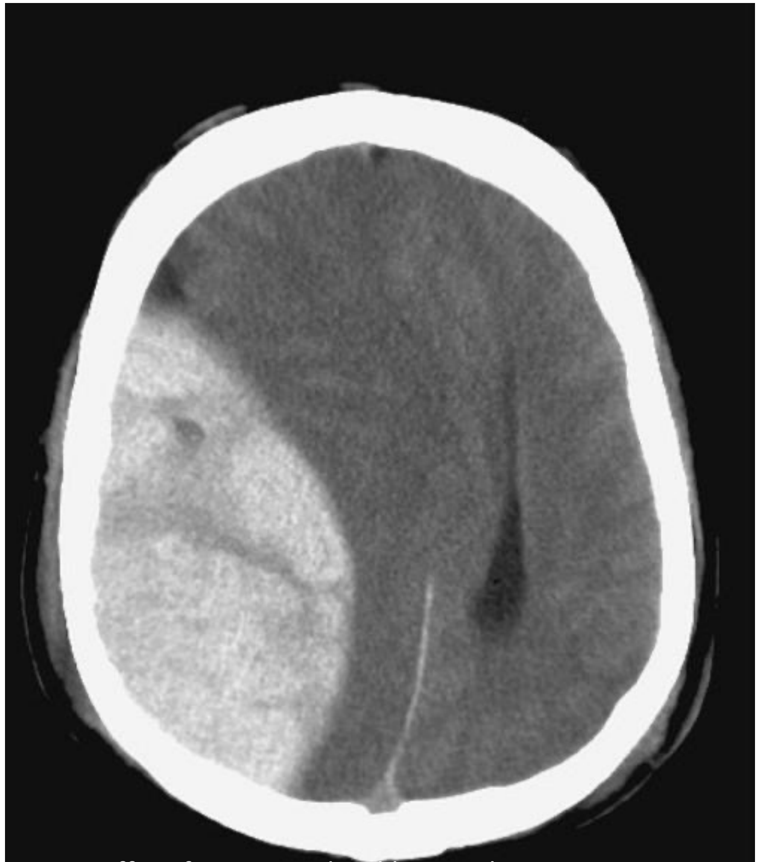


Dermatologist-level classification of skin cancer

Nature volume 542, pages 115–118 (02 February 2017)

Biomedical Text Processing

Classification of radiology reports using neural attention models, *IJCNN 2017*



Mass effect from extradural hemorrhage
https://radiopaedia.org

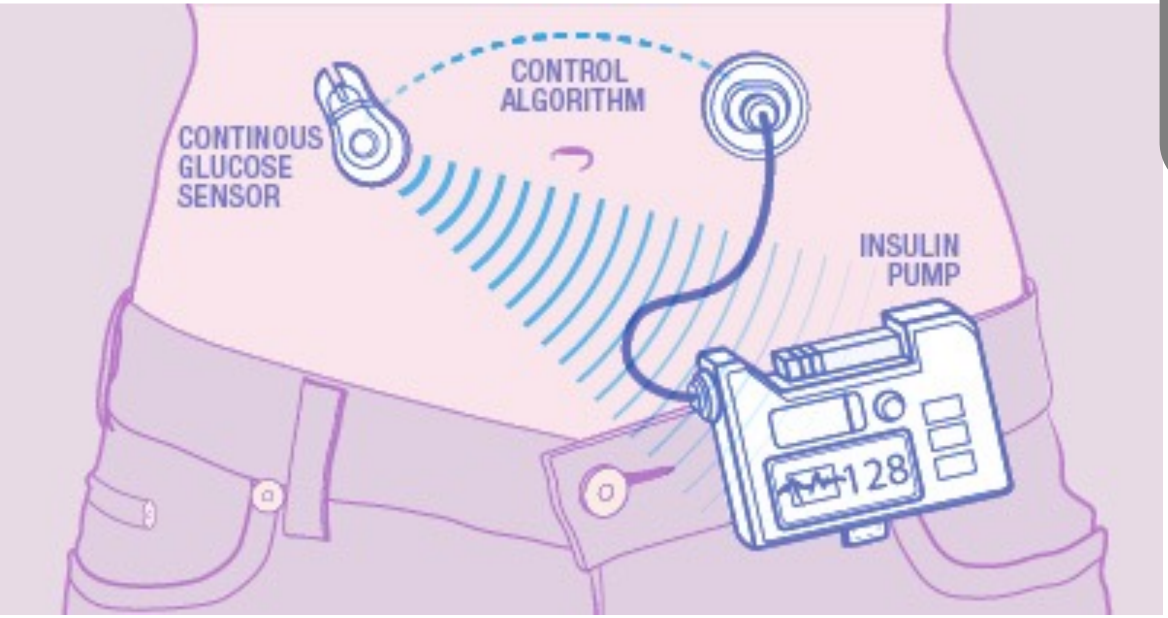
Table 5. Examples of correctly detected PHI instances (in bold) by the ANN

PHI category	ANN
AGE	Father had a stroke at **80** and died of?another stroke at age Personal data and overall health: Now **63**, despite his FH: Father: Died @ **52** from EtOH abuse (unclear exact etiology) Tobacco: smoked from age 7 to **15**, has not smoked since 15.
CONTACT	History of Present Illness **86F** reports worsening b/l leg pain. by phone, Dr. Ivan Guy. Call w/ questions **86383**. Keith Gilbert, H/O paroxysmal afib VNA **171-311-7974** ======= Medications
DATE	During his **May** hospitalization he had dysphagia Social history: divorced, quit smoking in **08**, sober x 10 yrs, She is to see him on the **29th** of this month at 1:00 p.m. He did have a renal biopsy in teh late **60s** adn thus will look for results, Results**02/20/2087** NA 135, K 3.2 (L), CL 96 (L), CO2 30.6, BUN 1 Jose Church, M.D. /ray DD: 01/18/20 DT: **01/19/:0** DV: 01/18/20

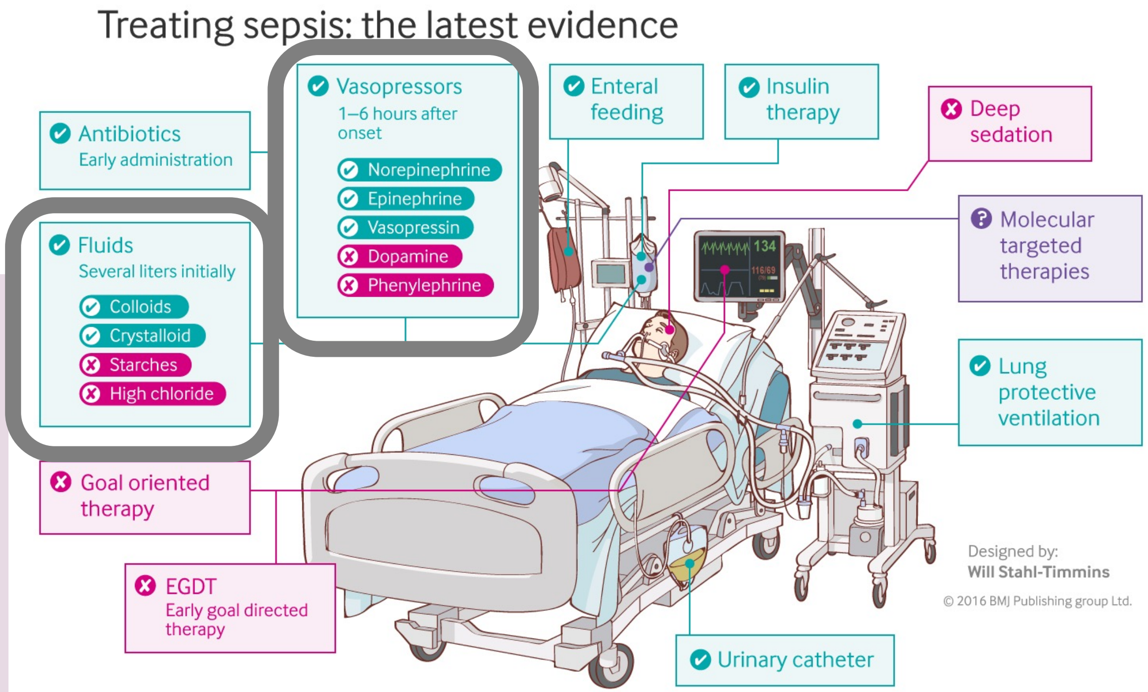
De-identification of patient notes with recurrent neural networks
JAMIA 24(3), 2017, 596–606

Sequential Prediction and Decision-Making Algorithms

Closed-loop blood glucose control ("artificial pancreas")



https://www.mayo.edu/research/labs/artificial-pancreas/overview



Fluid and vasopressor administration for sepsis treatment

Gotts JE, Matthay MA. Sepsis: pathophysiology and clinical management. bmj. 2016 May 23;353(i1585).

In each of these cases, we have a machine that receives data and makes a related prediction:

a “predictive model”

image -> prediction: computer vision

y, referrable diabetic retinopathy

x, retinal image

End goal: predict y from x

text -> prediction: natural language processing

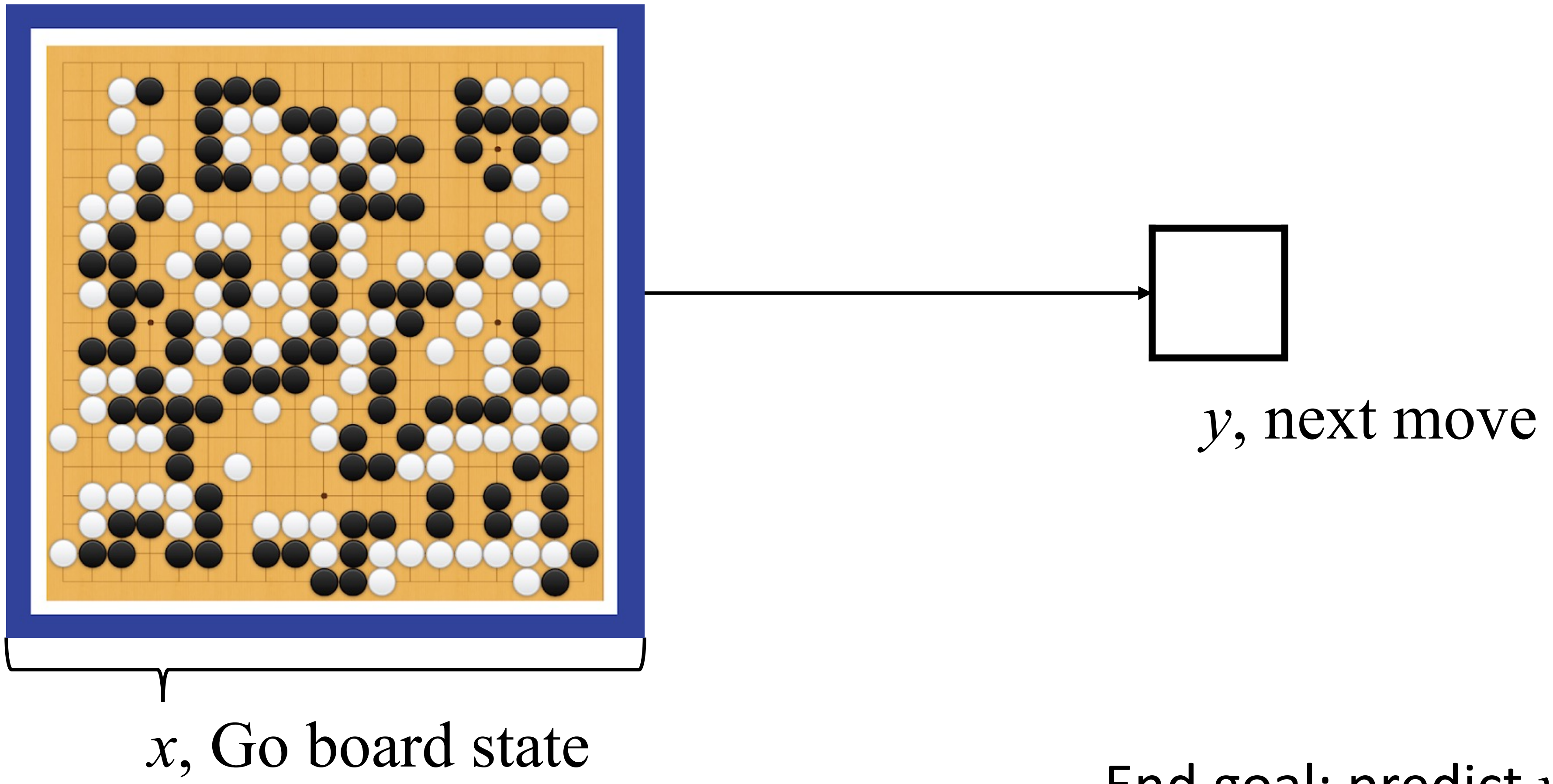
psychologist presenting problem NAME is a 3 year, 4 month old female who was referred for a neurodevelopmental assessment due to concerns regarding her overall development, behavior, and social emotional functioning and to

x, clinical note

y, autism risk

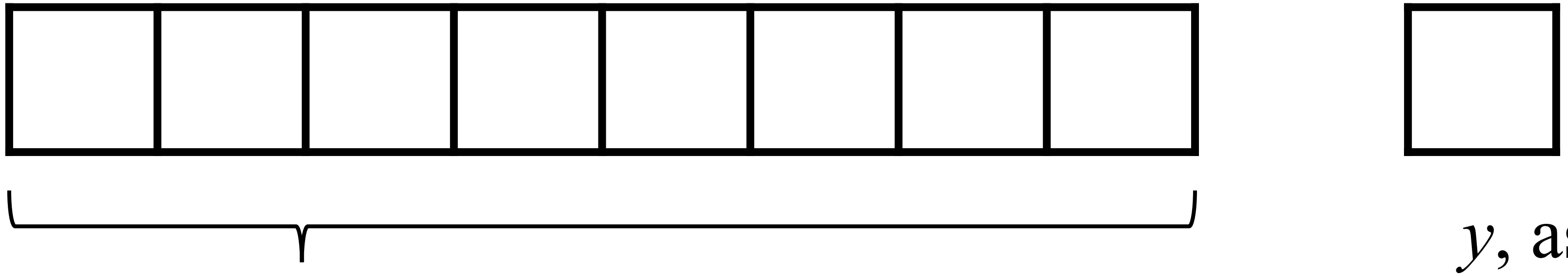
End goal: predict y from x

“state of the world” -> next action: reinforcement learning



End goal: predict y from x

features x -> prediction y: a predictive model

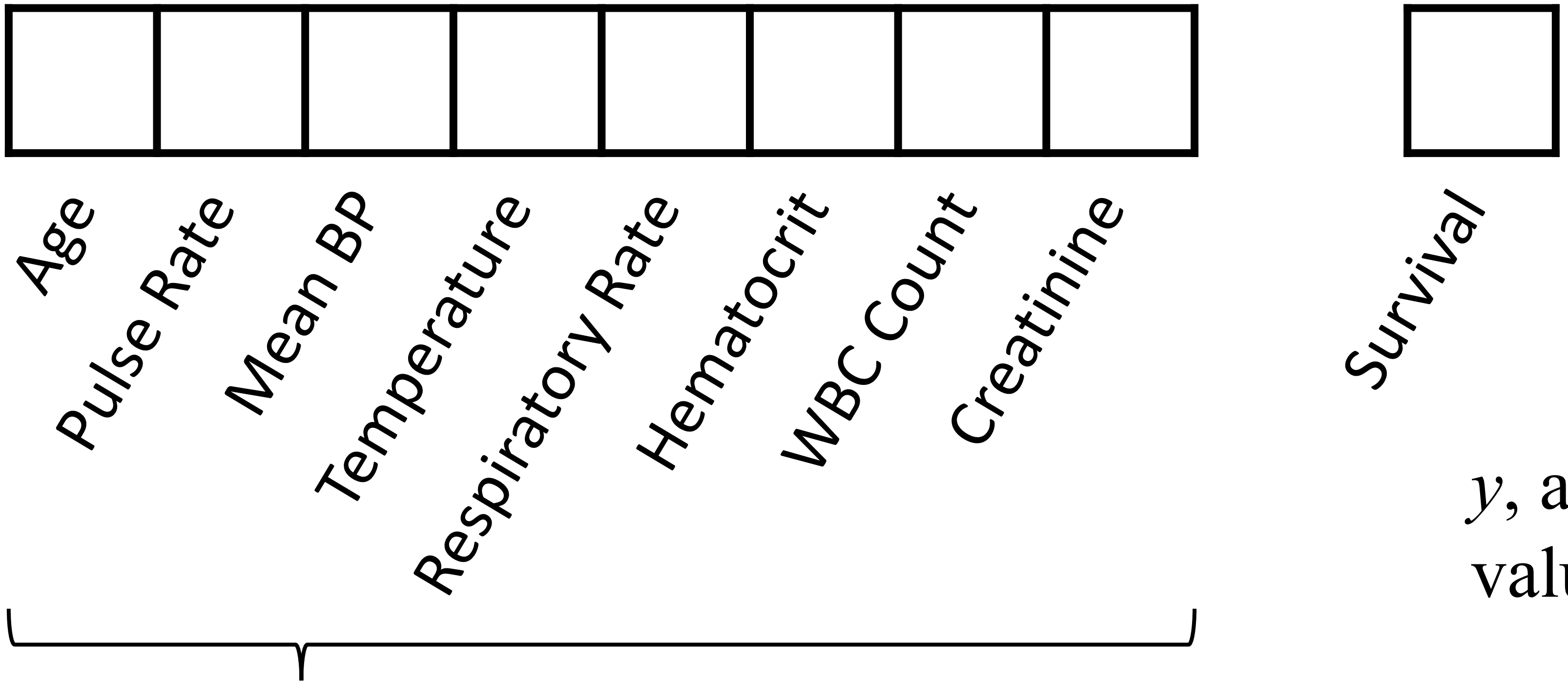


x, data/features for
a subject or patient

y, associated
value or label

End goal: predict *y* from *x*

Simple models often work well for clinical data!



y, associated value or label

x, data/features for a subject or patient

End goal: predict odds of hospital mortality (APACHE III)

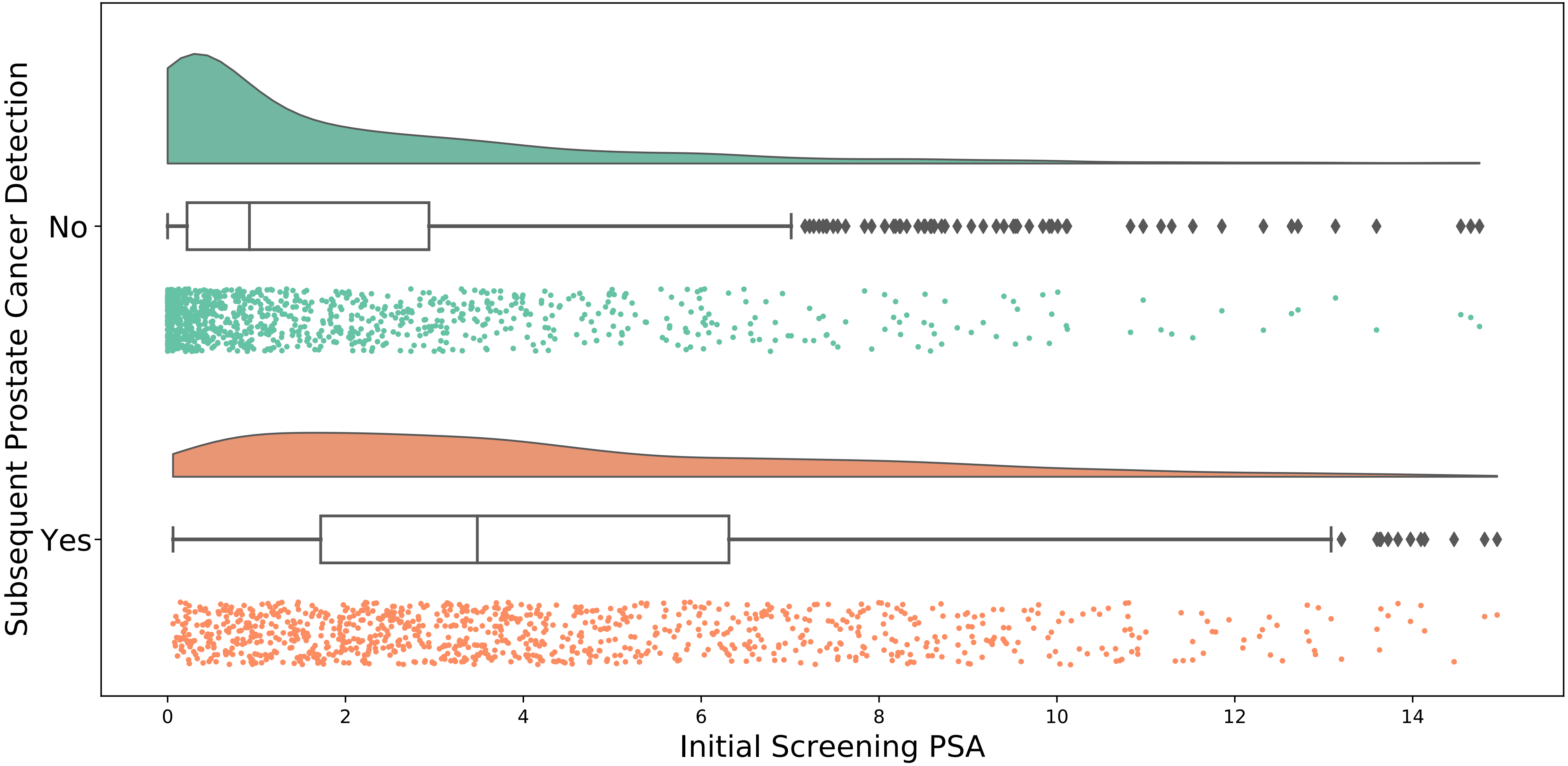
Before we tackle complex models, let's carefully examine a very simple one.

x, a single measurement:
prostate specific antigen

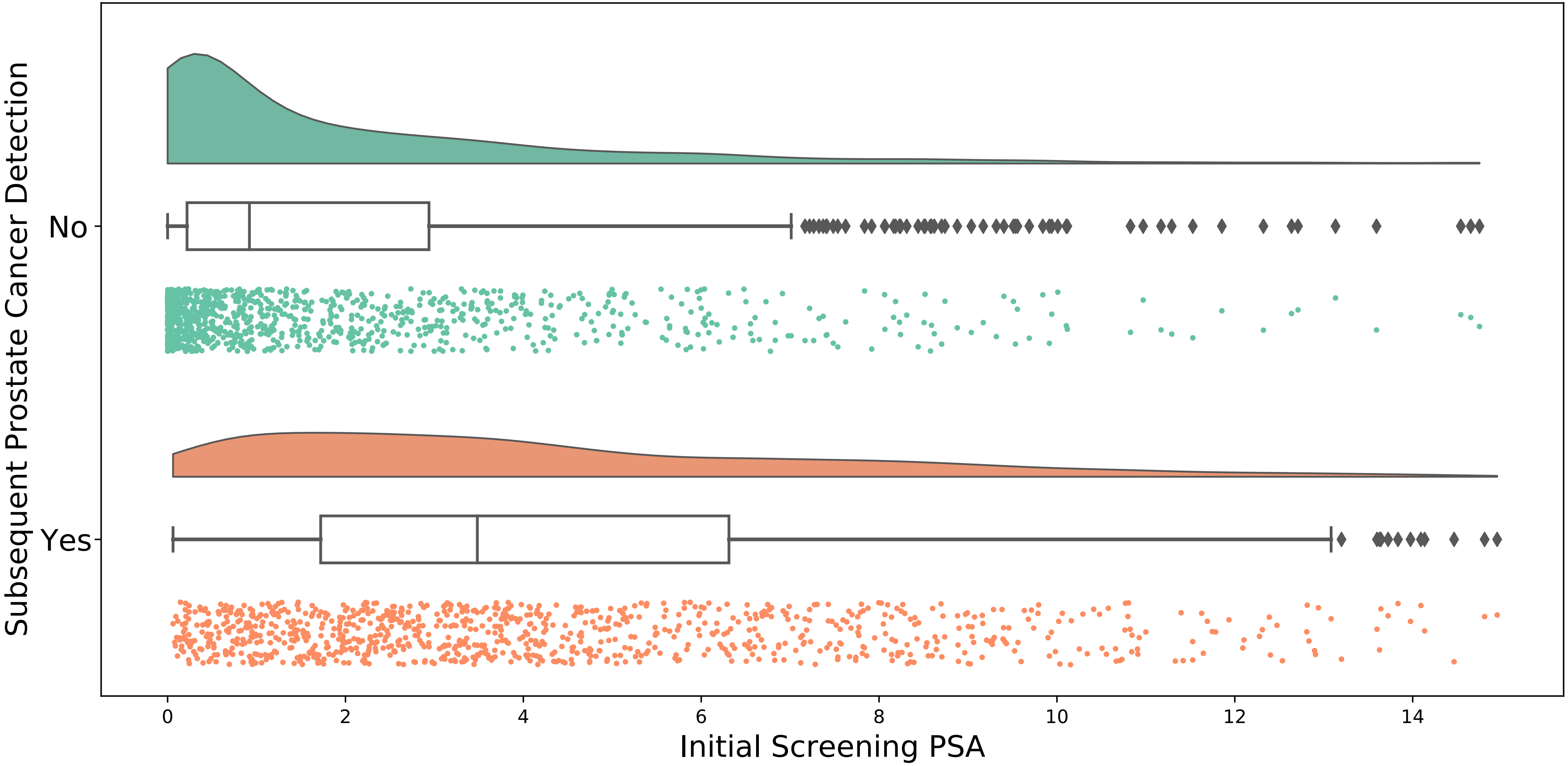
y, associated label:
prostate cancer
(0 = absent, 1 = present)

End goal: predict y from x

Prostate specific antigen measurement in individuals with vs without prostate cancer



End Goal: predict cancer status (y) based on PSA (x)



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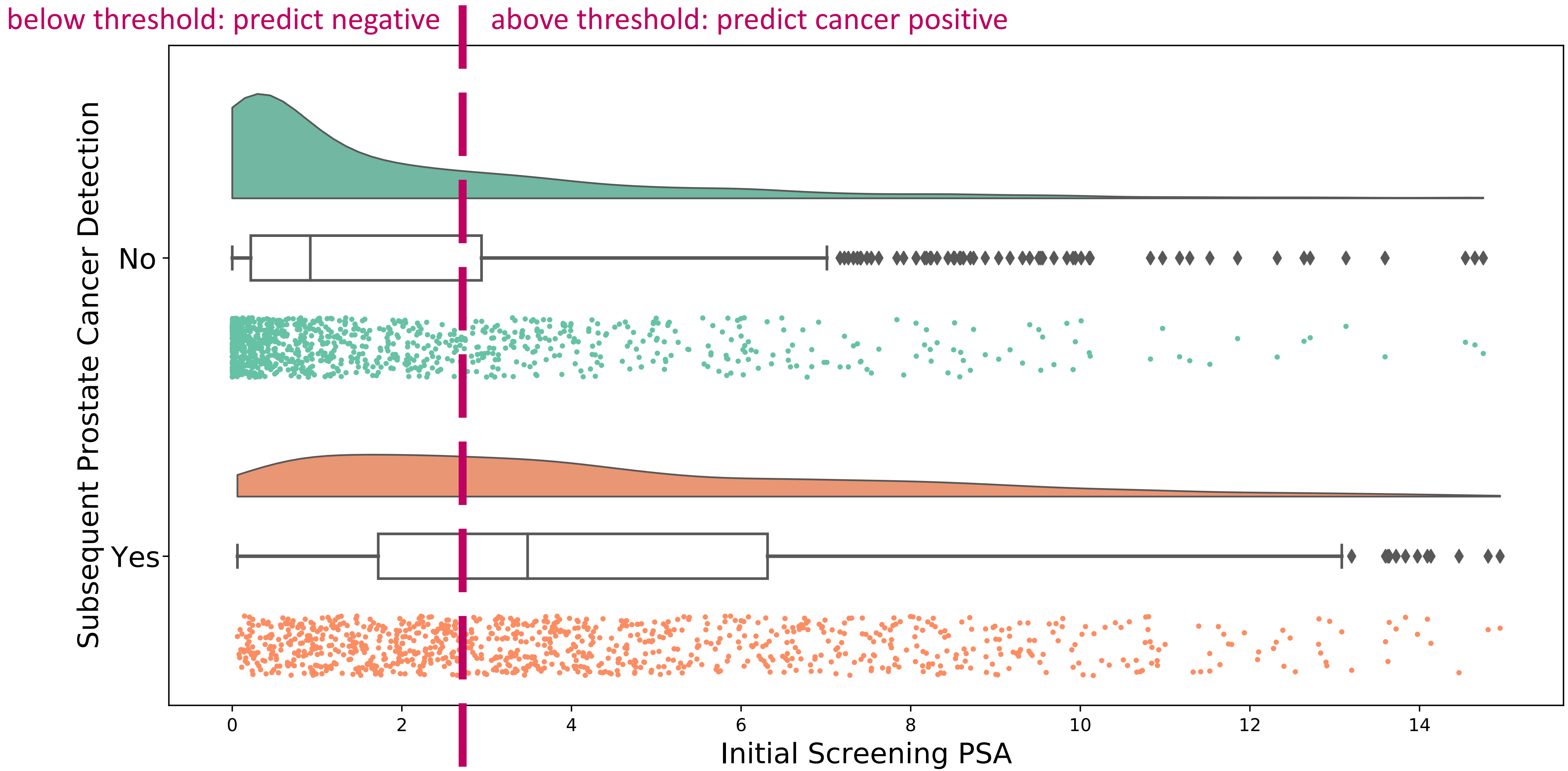

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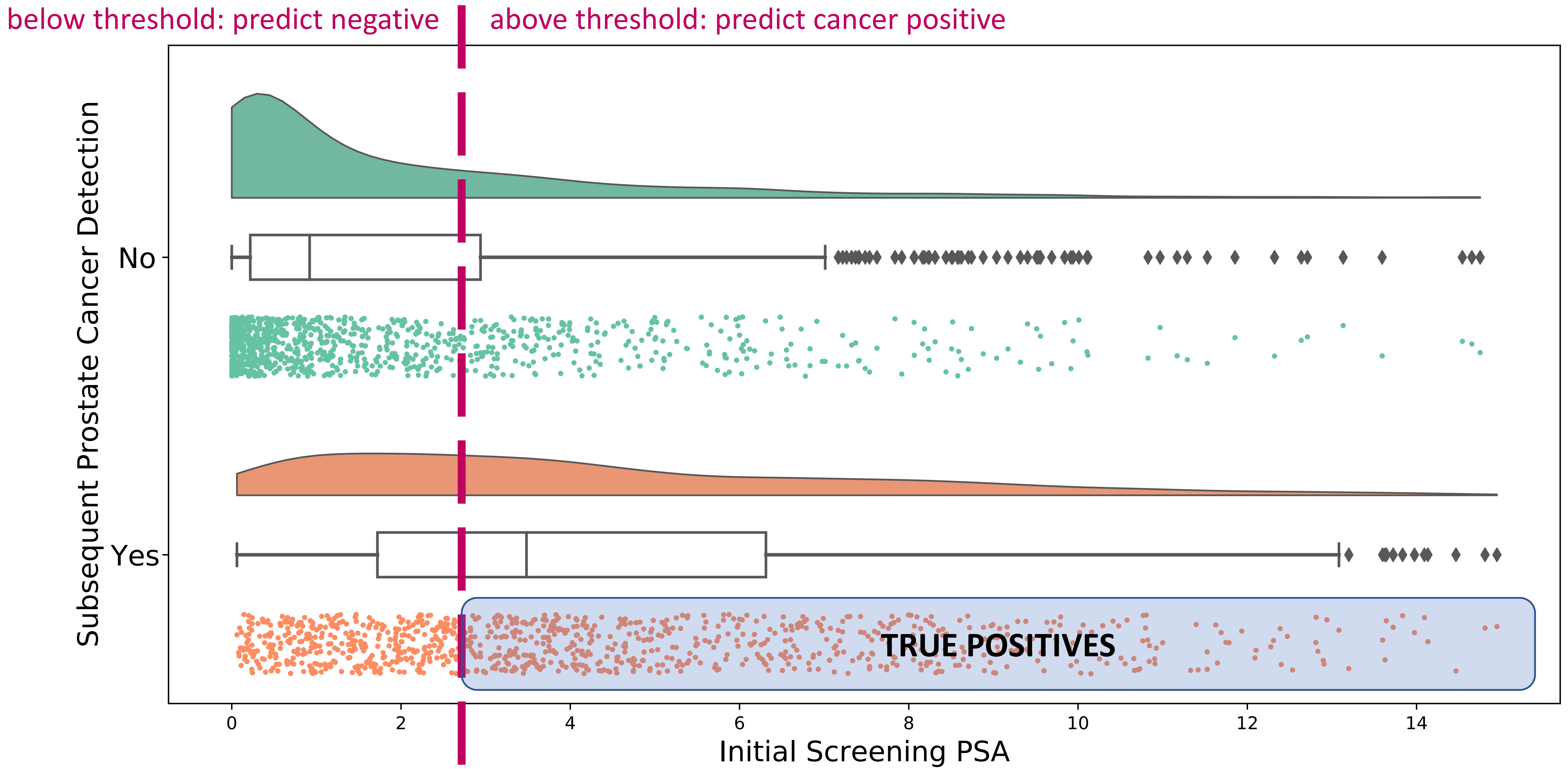

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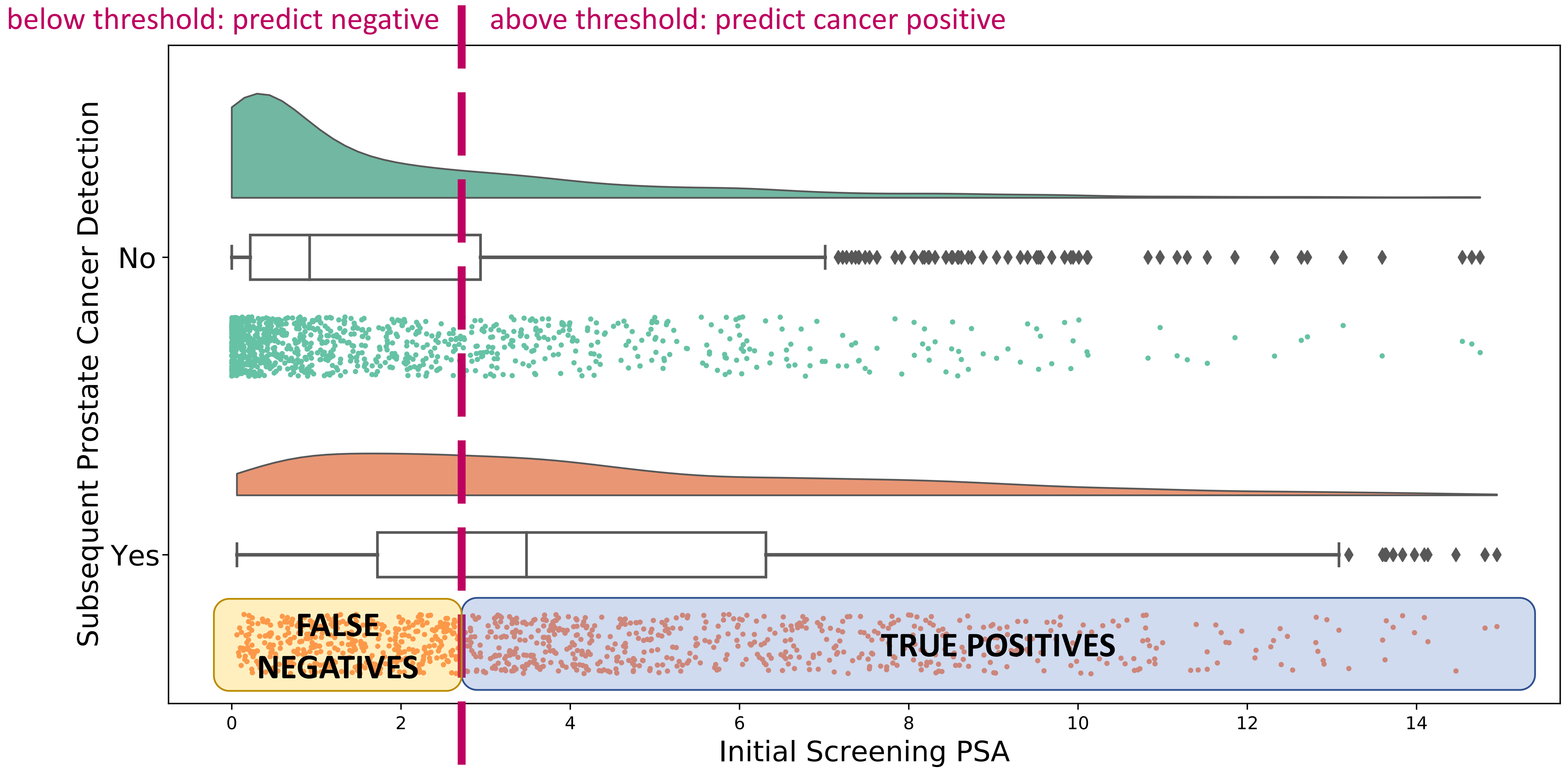

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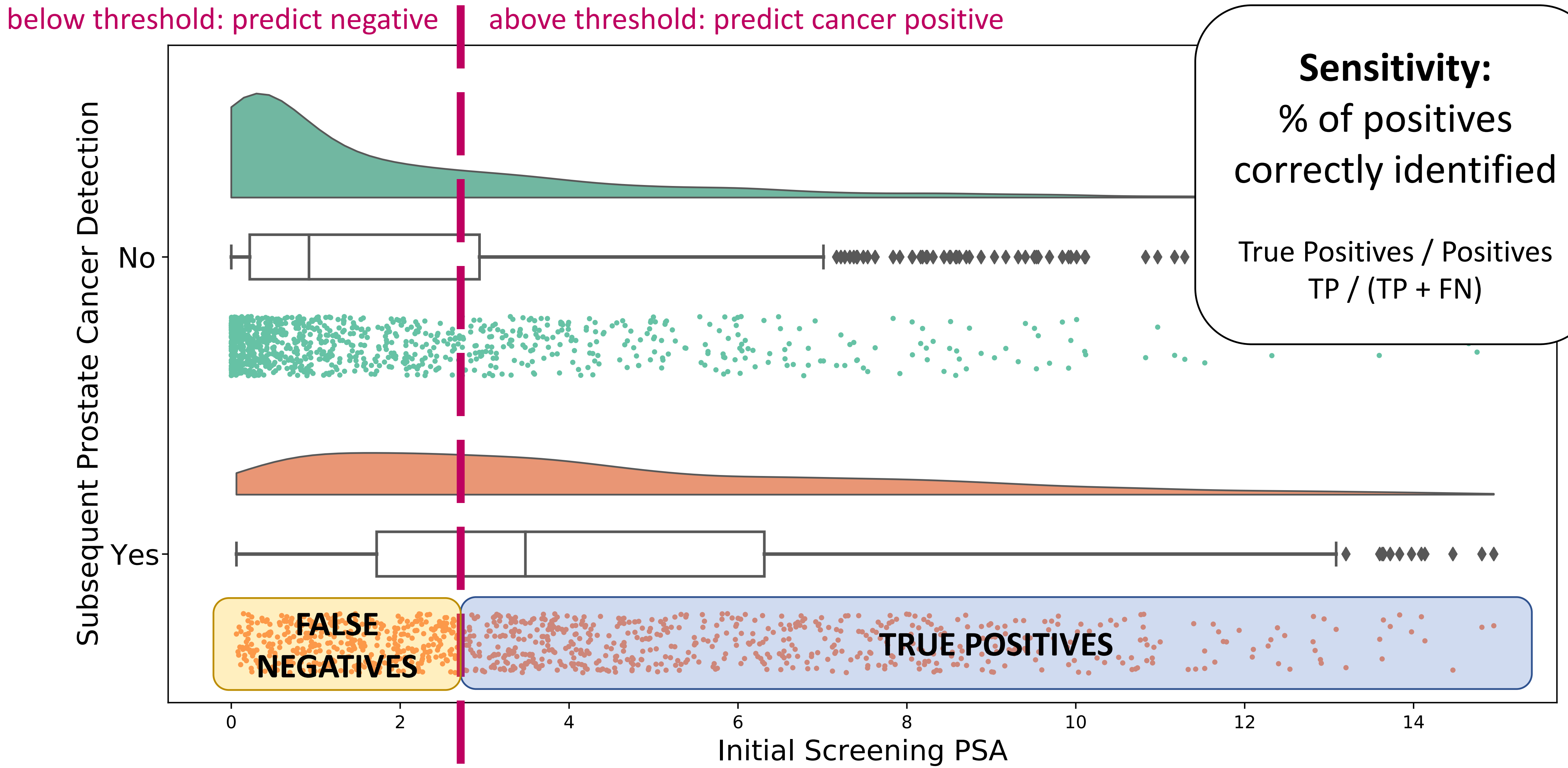


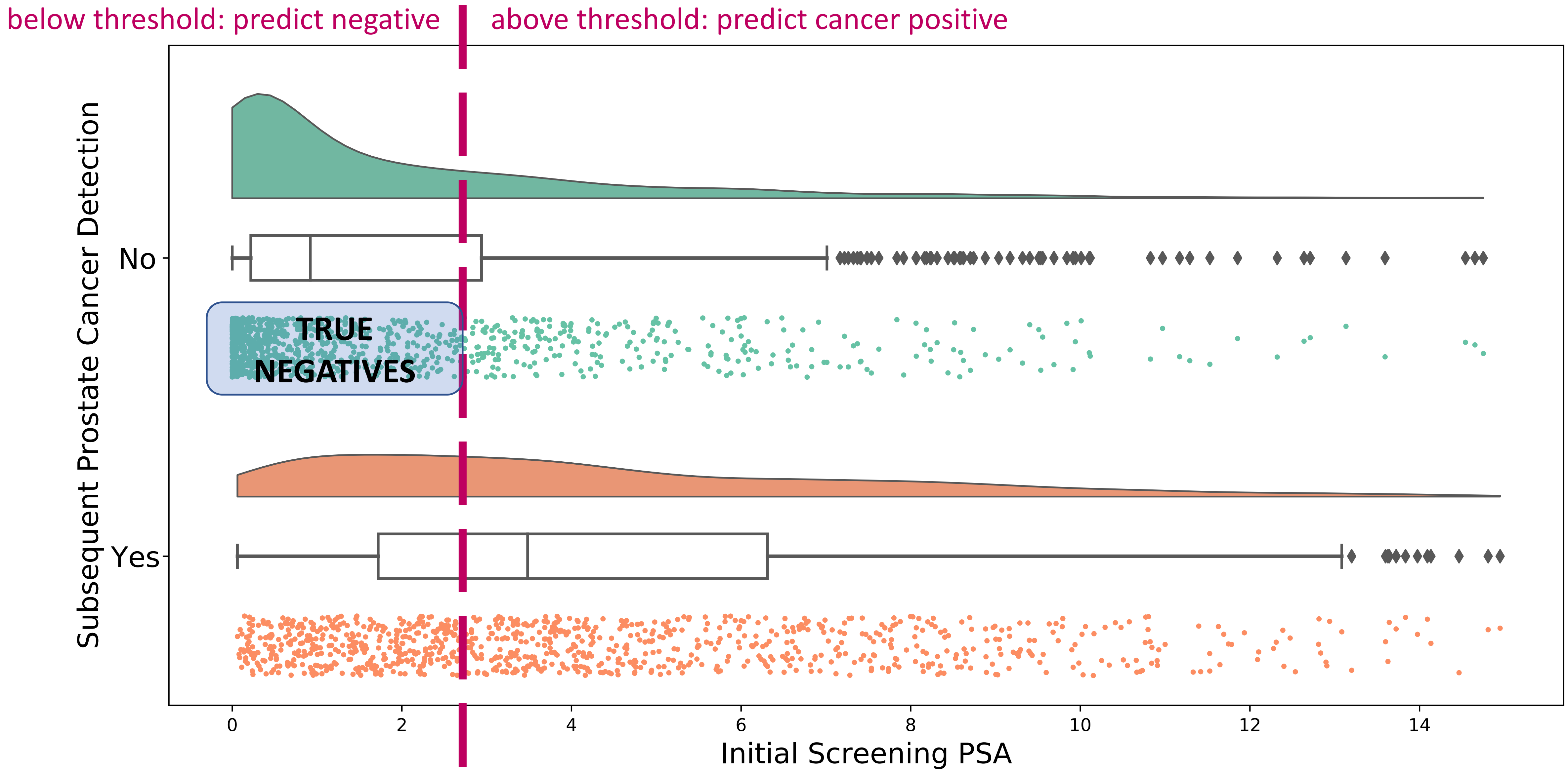
Sensitivity:

% of positives correctly identified

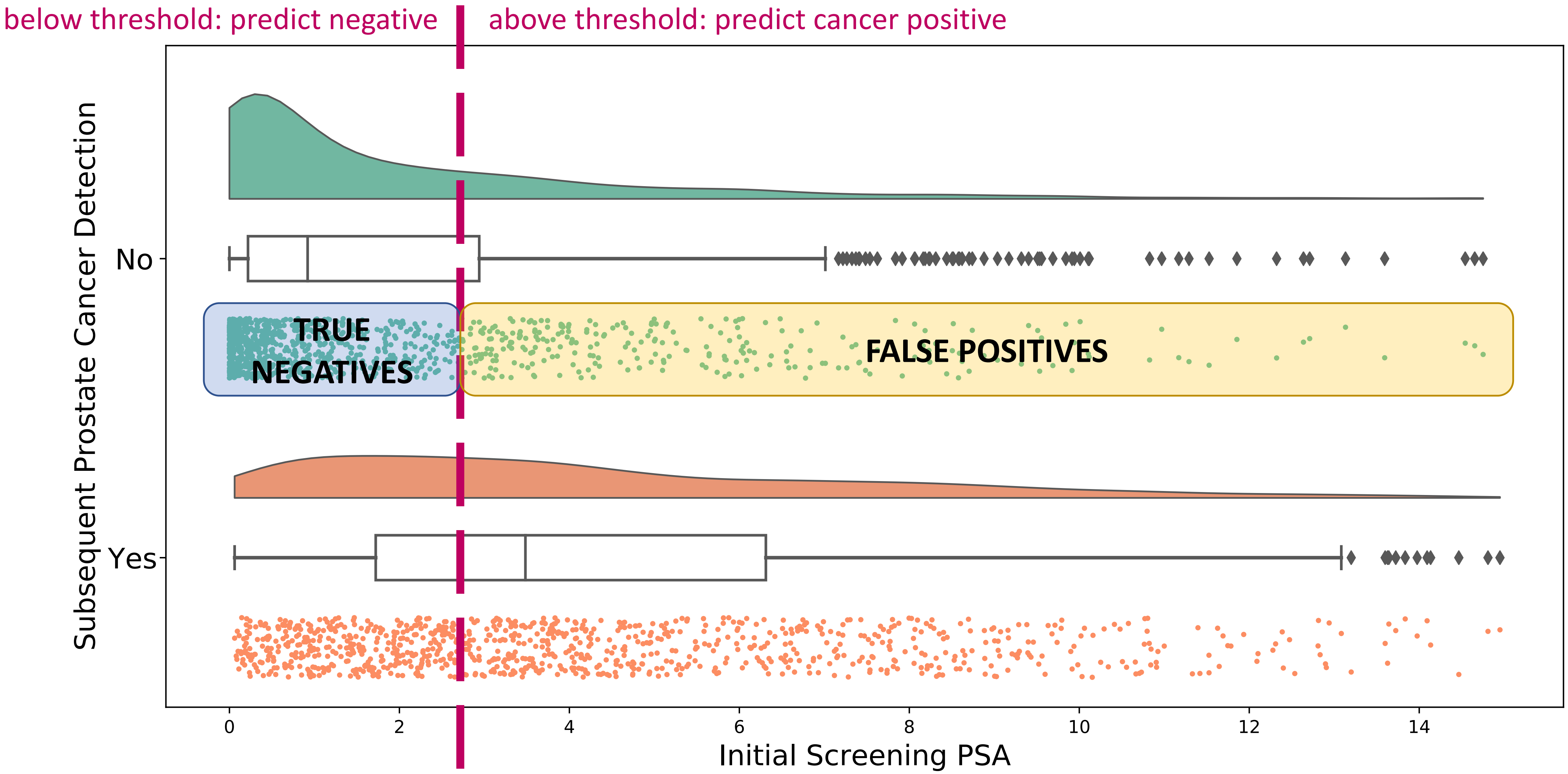
True Positives / Positives

TP / (TP + FN)

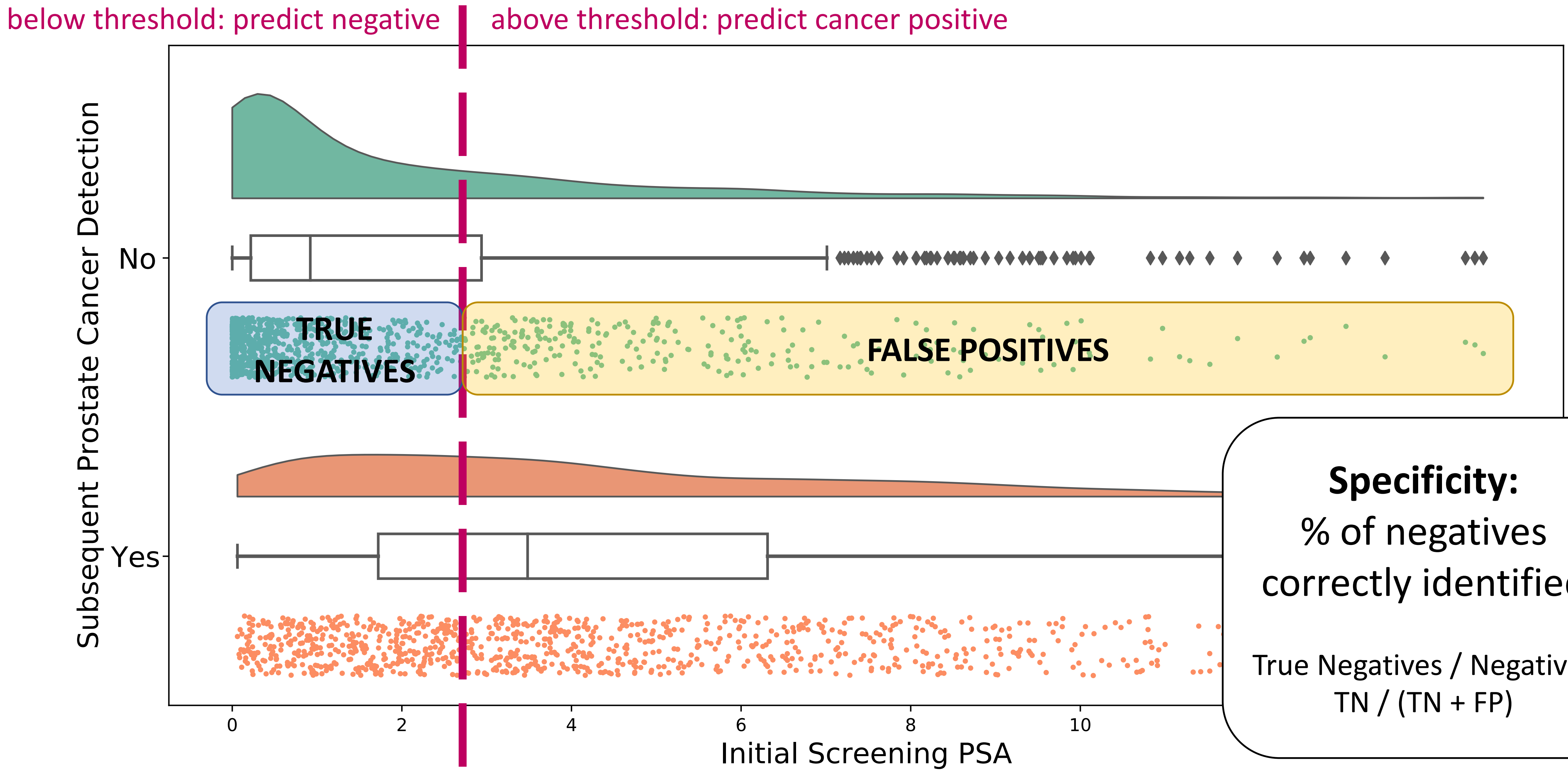
End Goal: predict cancer status (y) based on PSA (x)



End Goal: predict cancer status (y) based on PSA (x)



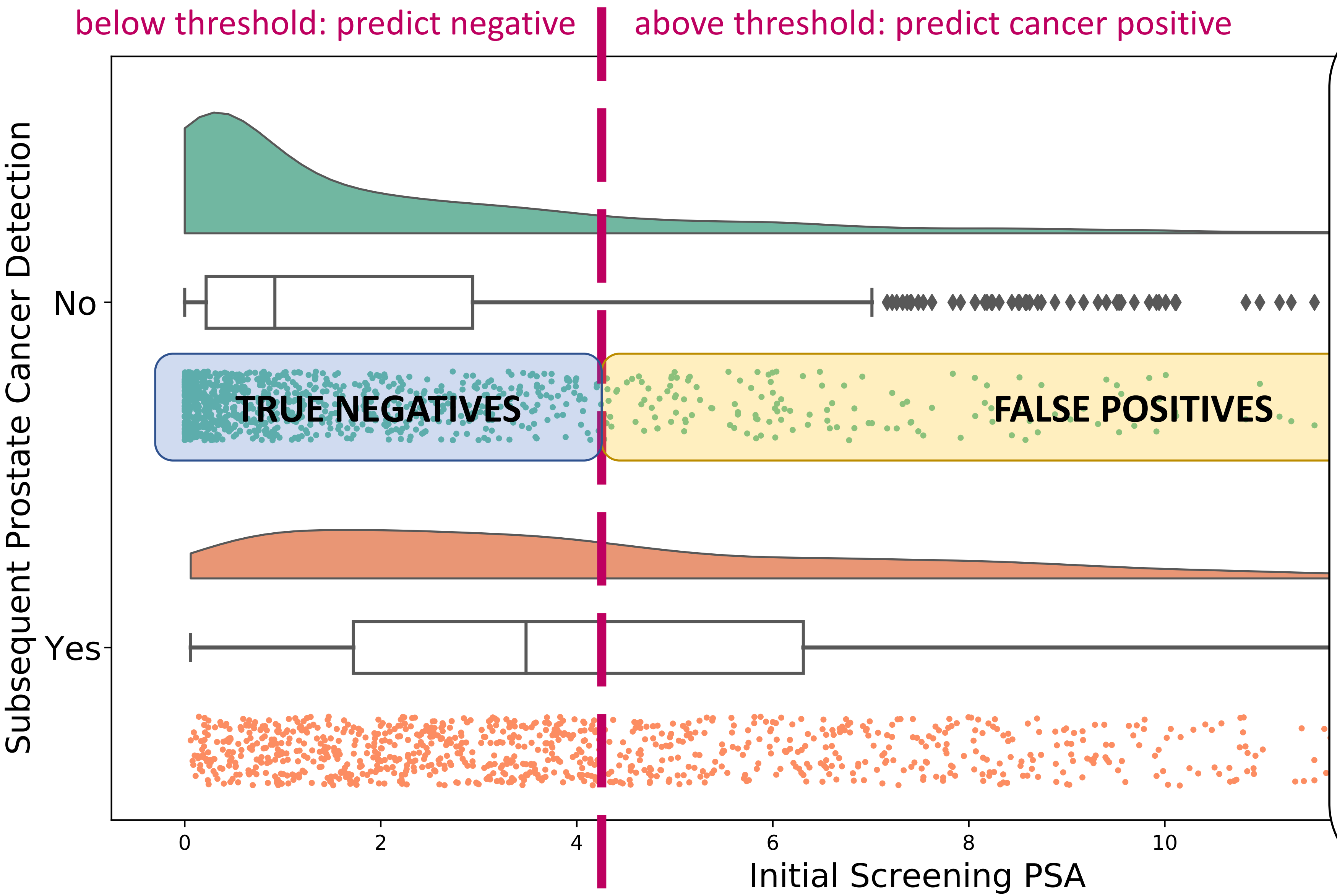
End Goal: predict cancer status (y) based on PSA (x)



Specificity:
% of negatives correctly identified

True Negatives / Negatives
TN / (TN + FP)

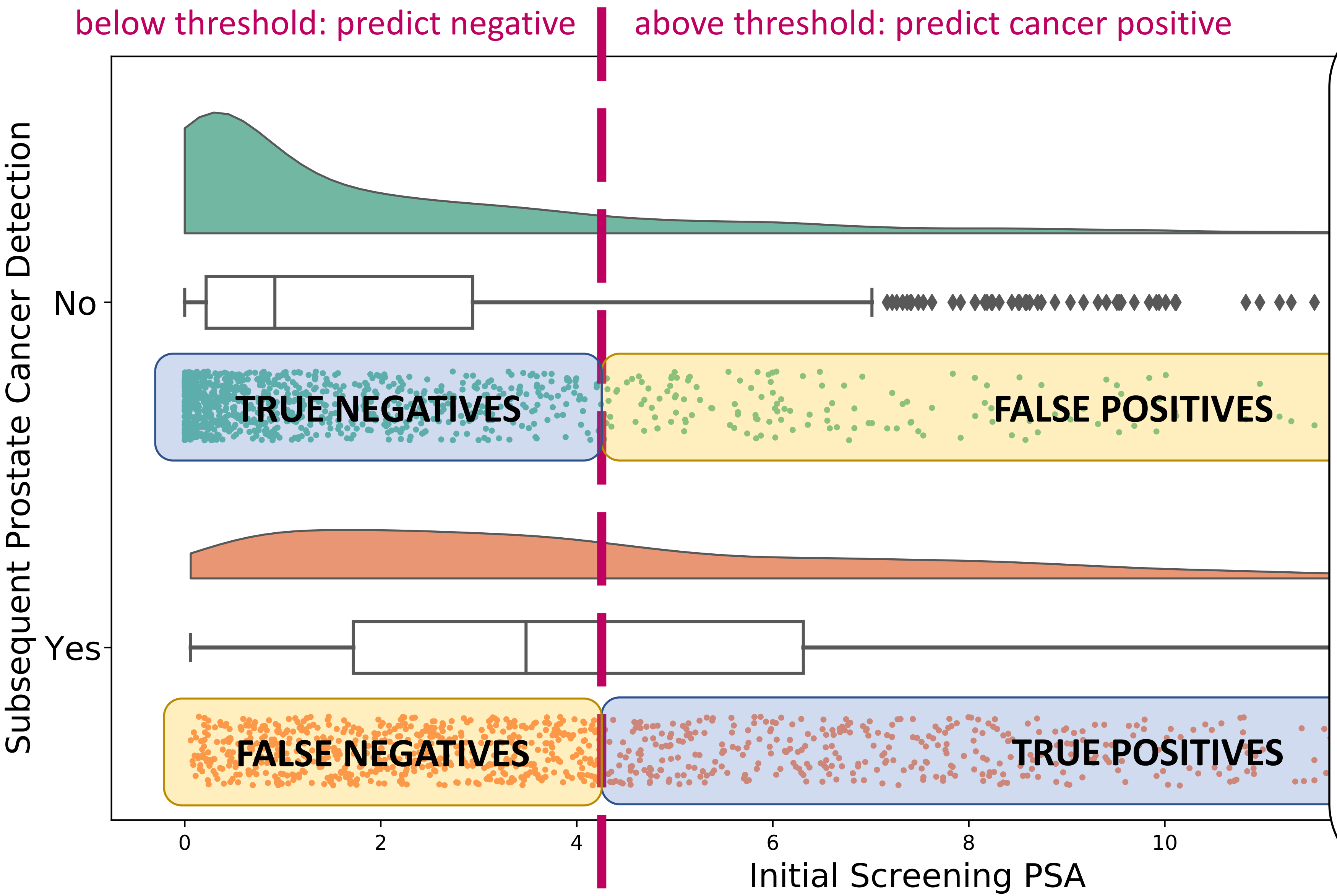
End Goal: predict cancer status (y) based on PSA (x)



Increase the threshold:

1. Specificity goes up. (we're catching more negative cases)

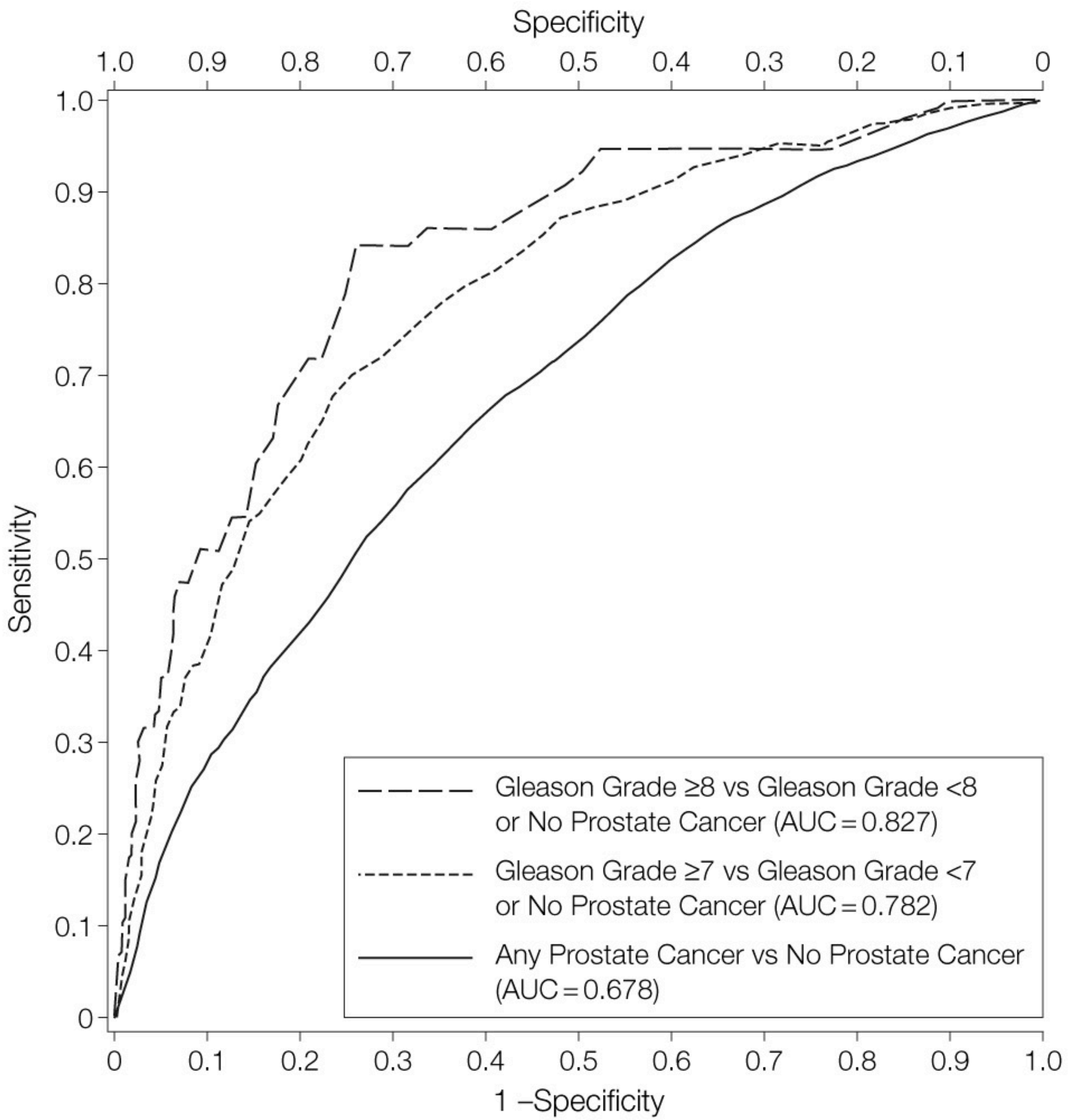
End Goal: predict cancer status (y) based on PSA (x)



Increase the threshold:

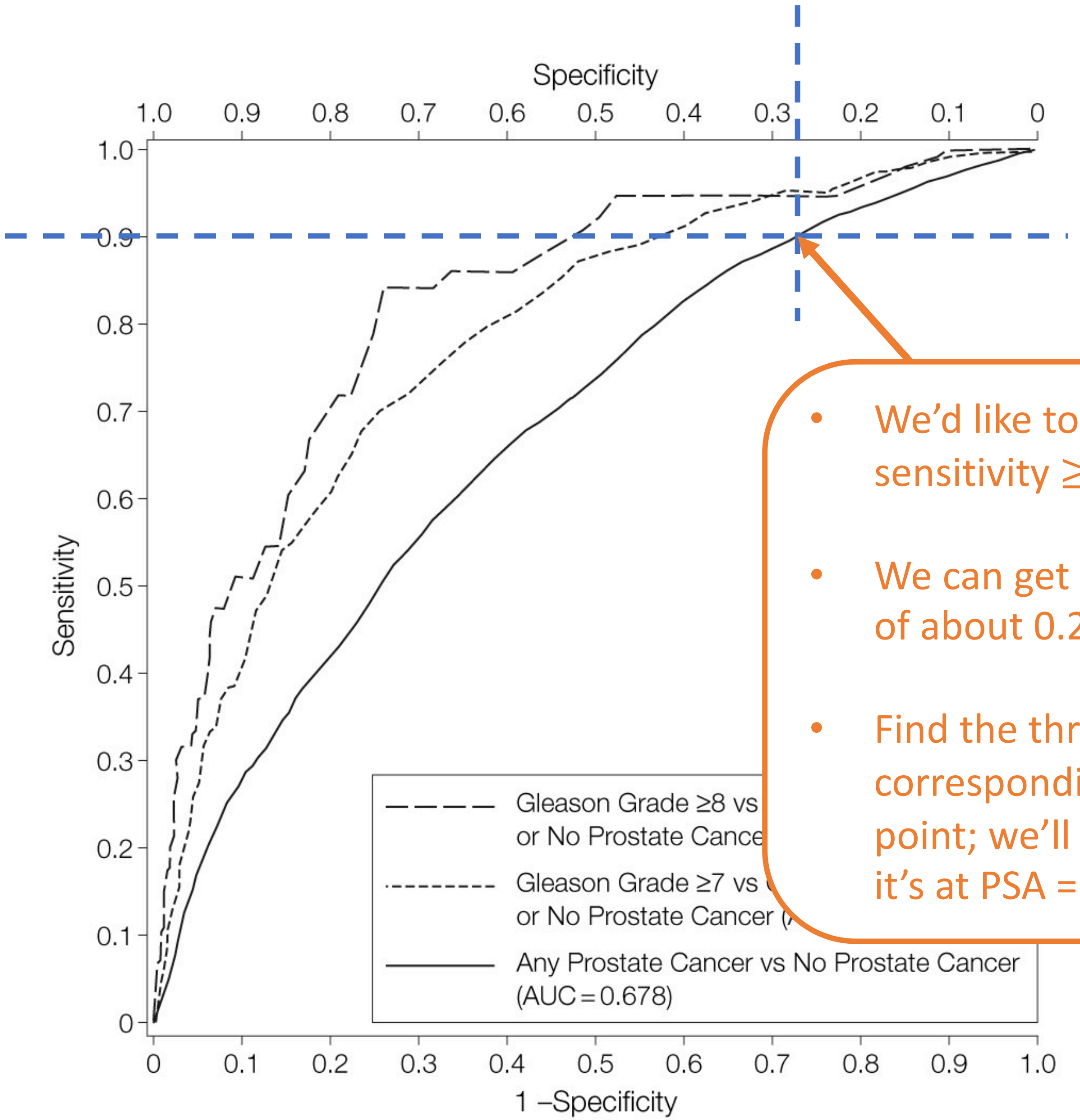
1. Specificity goes up. (we’re catching more negative cases)

2. Sensitivity goes down. (we’re catching fewer positive cases)



The ROC curve
(i.e. sensitivity/specificity curve) quantifies performance across all possible thresholds

Thompson IM, Ankerst DP, Chi C, et al. Operating Characteristics of Prostate-Specific Antigen in Men With an Initial PSA Level of 3.0 ng/mL or Lower. *JAMA.* 2005;294(1):66–70. doi:10.1001/jama.294.1.66



- We'd like to have sensitivity ≥ 0.9
- We can get specificity of about 0.27
- Find the threshold corresponding to this point; we'll suppose it's at PSA = 2.0

The ROC curve
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Thompson IM, Ankerst DP, Chi C, et al. Operating Characteristics of Prostate-Specific Antigen in Men With an Initial PSA Level of 3.0 ng/mL or Lower. *JAMA.* 2005;294(1):66–70. doi:10.1001/jama.294.1.66

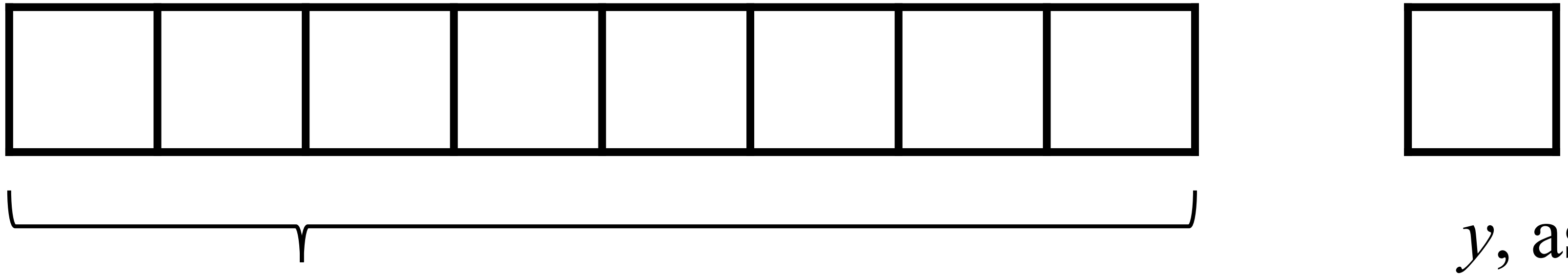
Our first, very simple predictive model

End Goal: predict cancer status (y) based on PSA (x)

Our rule:

if PSA > 2.0, **predict** positive
else predict negative

Learning a Predictive Model from Labeled Data

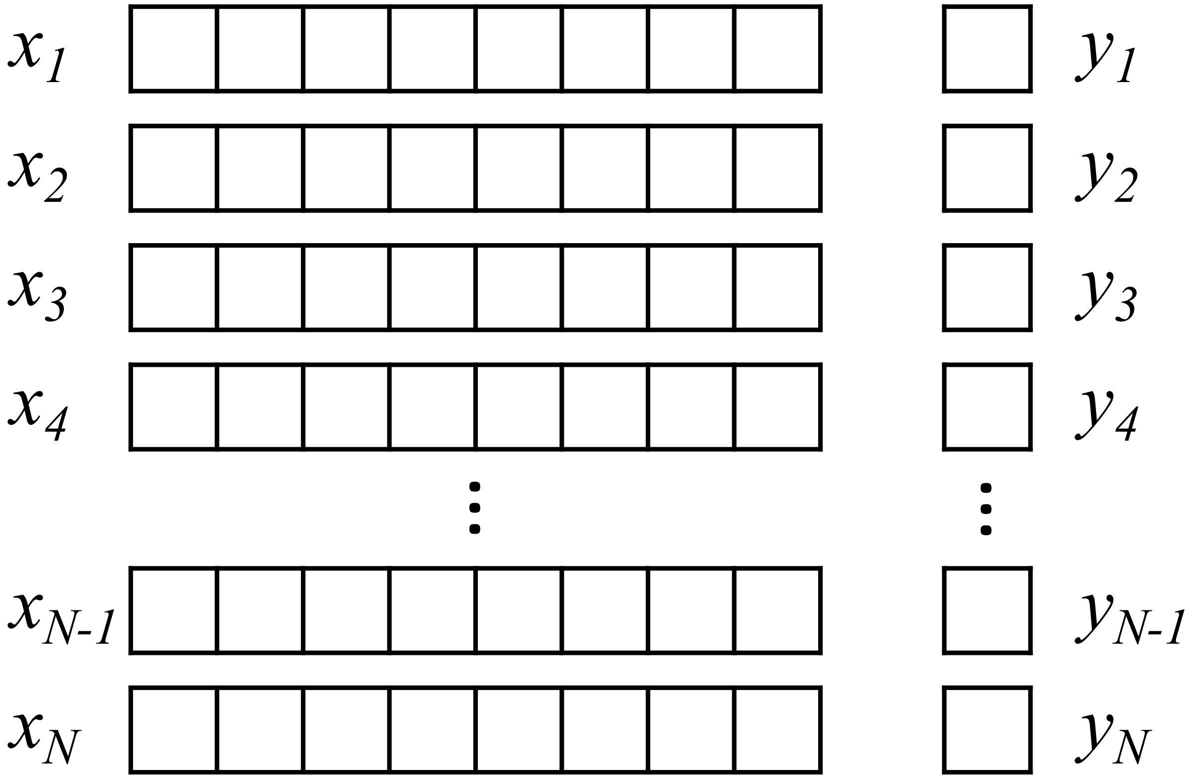


x, data/features for a subject or patient

y, associated value or label

The learning process: find the equation that best predicts *y* based on *x*

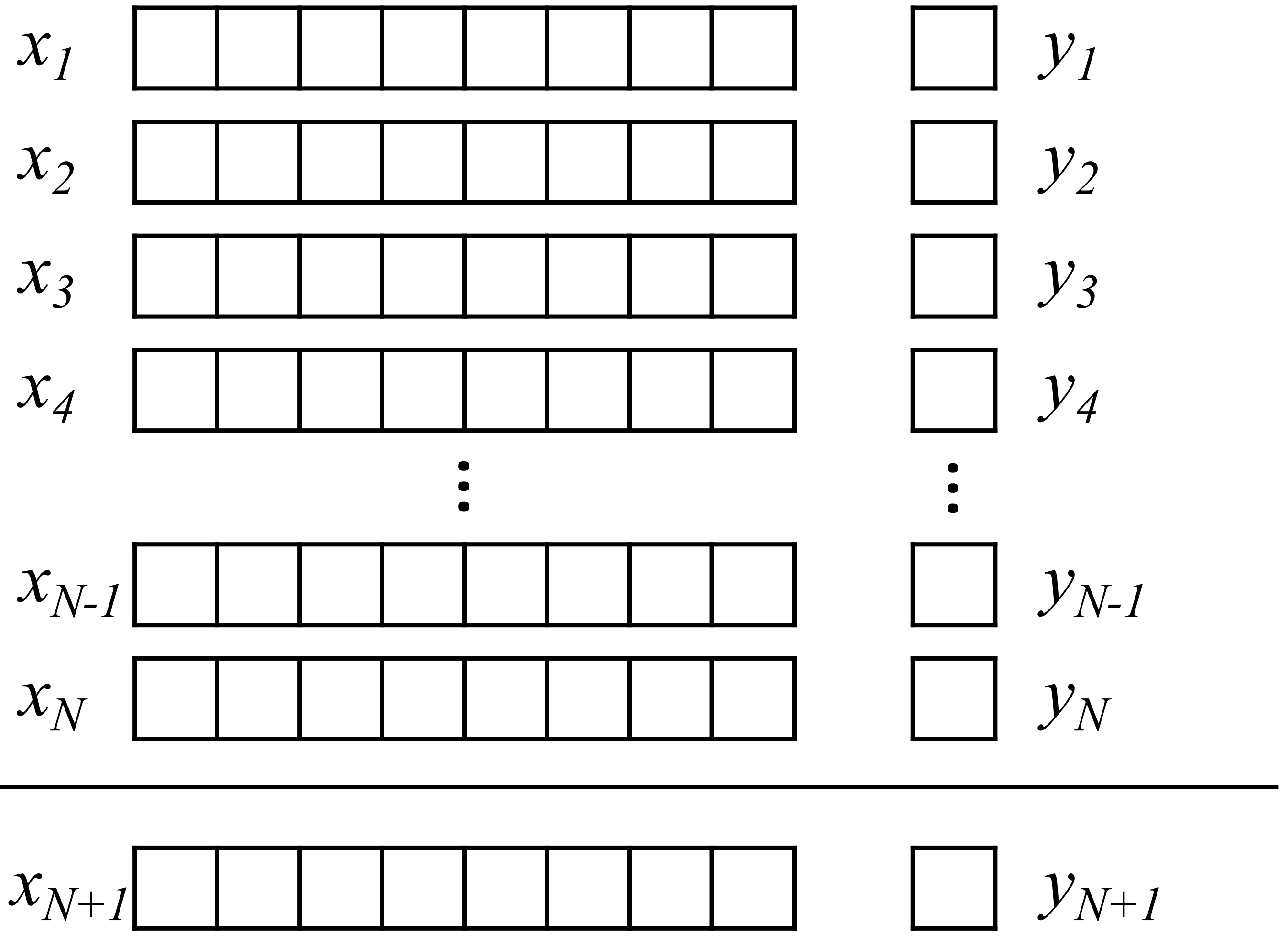
Training Set (Historical Data)



Find an equation that predicts y based on x across the training set

We'll begin by supposing y is binary (i.e. $y \in \{0, 1\}$)

Making Predictions for New x



Find an equation that predicts y based on x across the training set

We'll begin by supposing y is binary
(i.e. $y \in \{0, 1\}$)

<- Learn to predict new y

Summary

- The data science techniques we will consider in this course, from computer vision to natural language processing, are all examples of *predictive models*.

- The predictive model is the *machine* in machine learning. It is a specific mathematical equation that is learned from historical data and evaluated by applying it to additional data not used in training.

- Predictive models can be very simple or very complex. As a rule of thumb, we want to <u>use the simplest model that performs well</u>.