TEST ACCURACY

Clinical Informatics Lecture

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Learning objectives

- Develop an intuitive understanding of analytical accuracy
- Define common metrics of analytical accuracy
- Apply accuracy based metrics to evaluate a diagnostic test

Course materials at: https://github.com/MarkZaydman/Lecture-TestAccuracy.git

Why this lecture matters

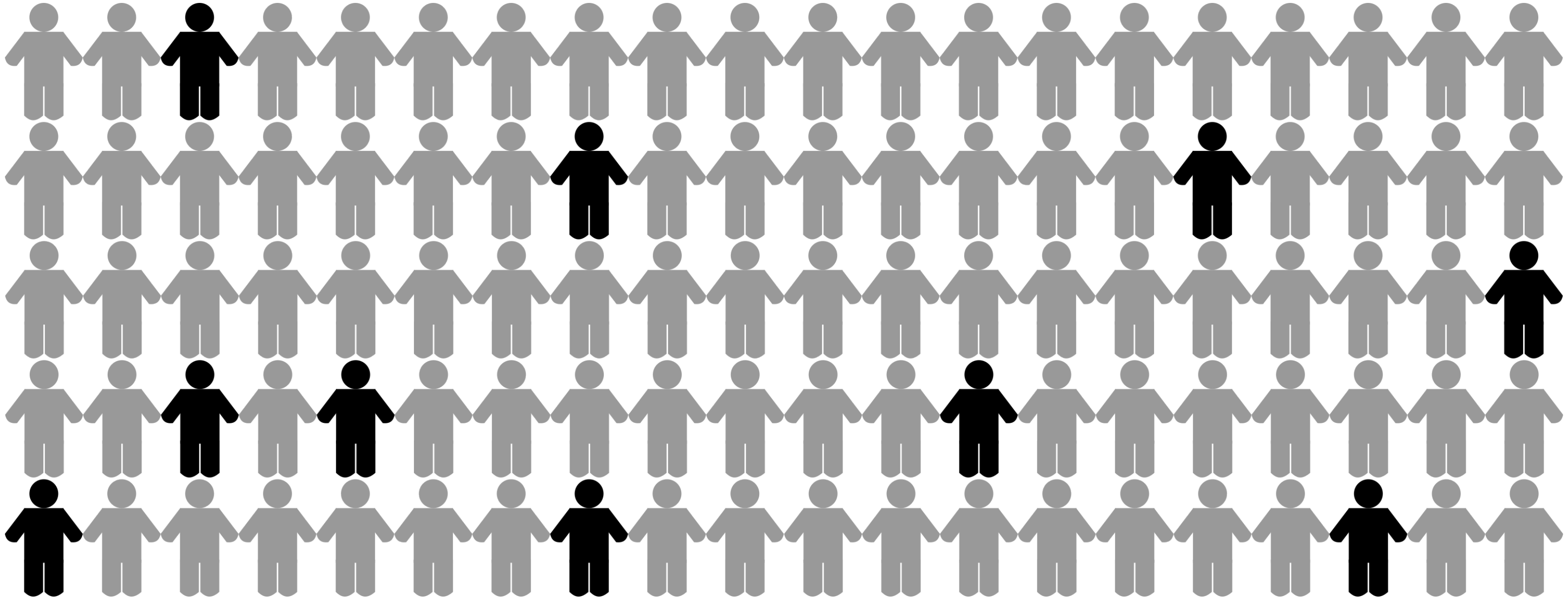
- Critically evaluating laboratory tests is a core function of a clinical pathologist
- Accuracy metrics are highly testable

2x2 Contingency Tables

<u>**Disease Status**</u>	Test Positive	Test Negative
Diseased	True Positive (TP)	False Negative (FN)
Healthy	False Positive (FP)	True Negative (TN)

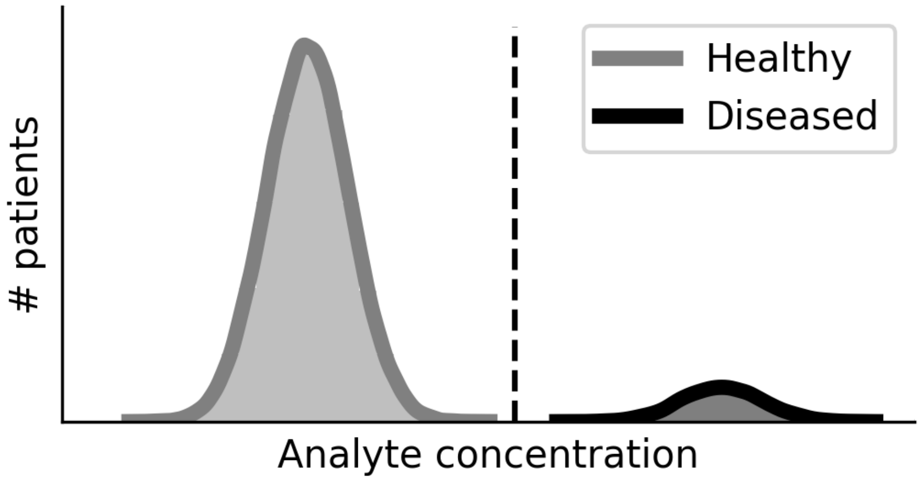
Instead of focusing on this table this lecture aims to develop an intuition of test accuracy

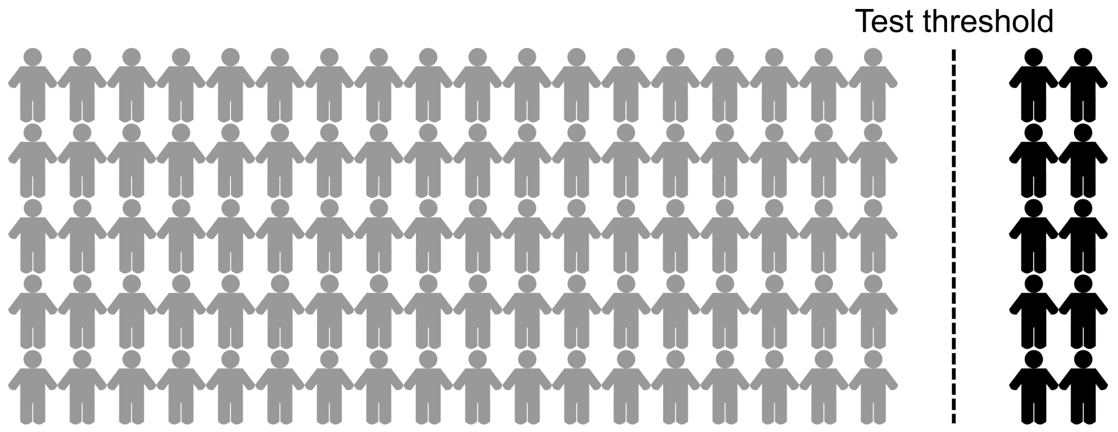
What is the point of performing a diagnostic test?



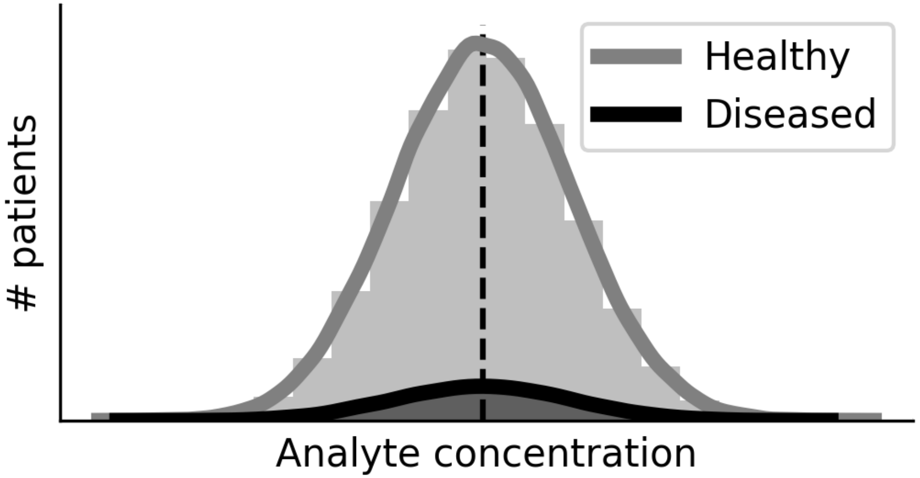
Prevalence =0.1

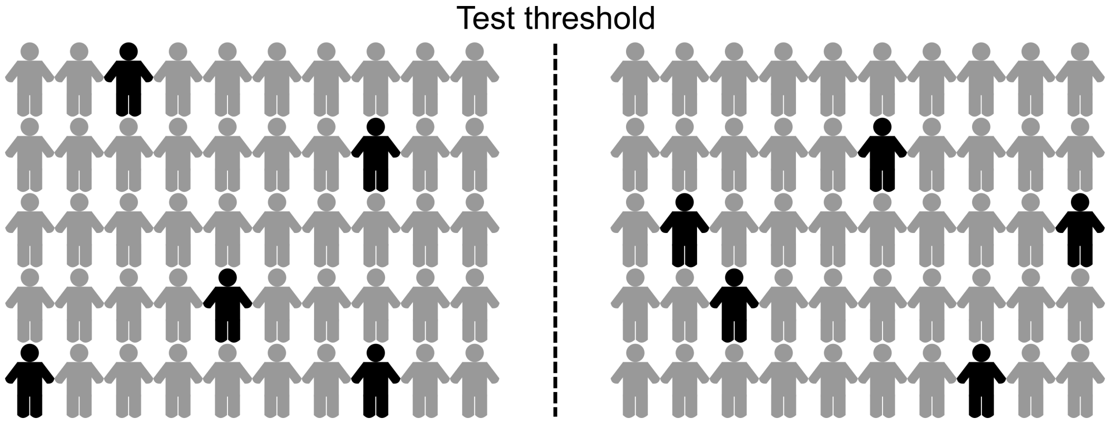
An ideal test fully separates healthy & diseased



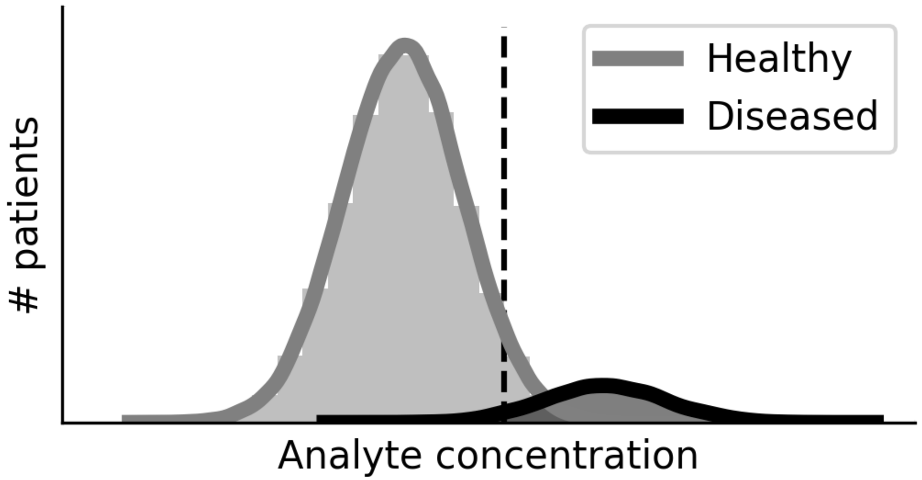


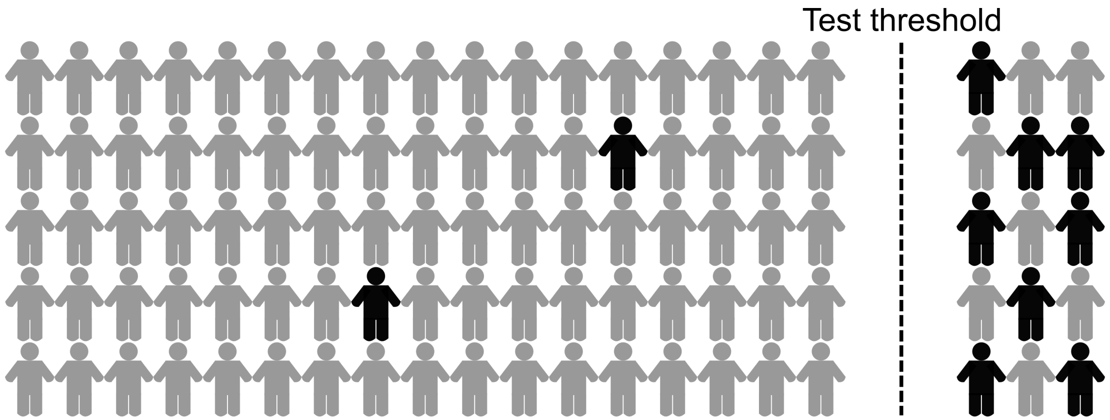
An useless test does not separate healthy & diseased

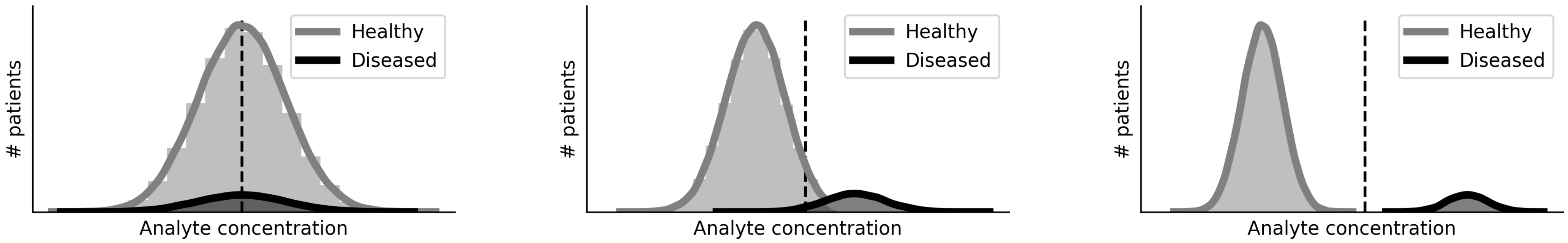




An realistic test partially separates healthy & diseased







Test Accuracy

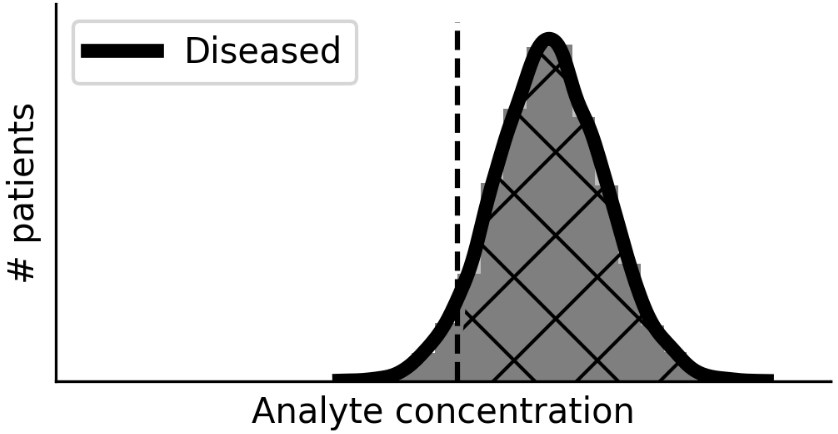
The degree to which results from healthy and diseased individuals can be separated by a decision boundary (diagnostic threshold)

Concepts To Be Discussed Today

1. Sensitivity, Specificity, and ROCC Analysis
2. Positive and Negative Predictive Values
3. Likelihood Ratios and Diagnostic Odds Ratio

Sensitivity, Specificity, and ROCC Analysis

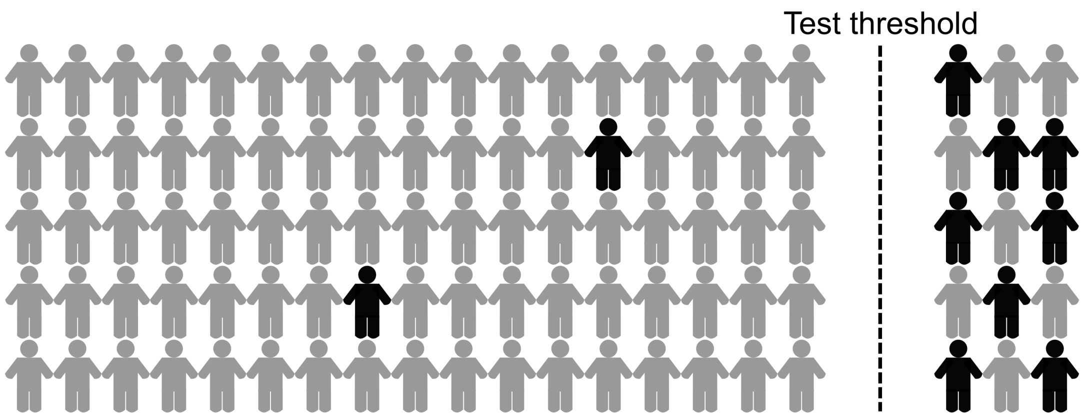
Sensitivity (Se)

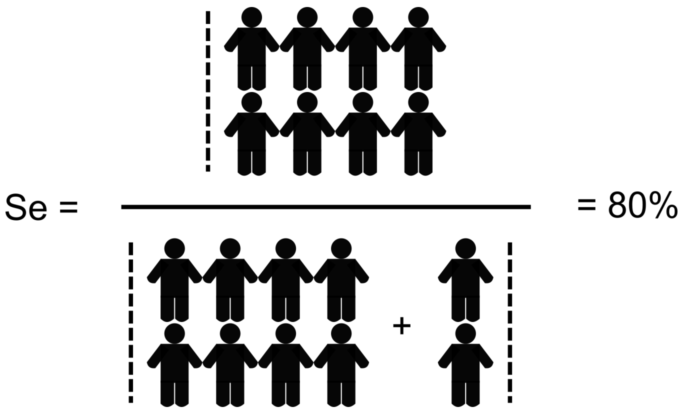


$$Se = \frac{TP}{TP+FN}$$

1. Se is the fraction of diseased individuals that test positive
2. Se varies from zero to one
3. Se decreases with increasing threshold value

Sensitivity calculation example



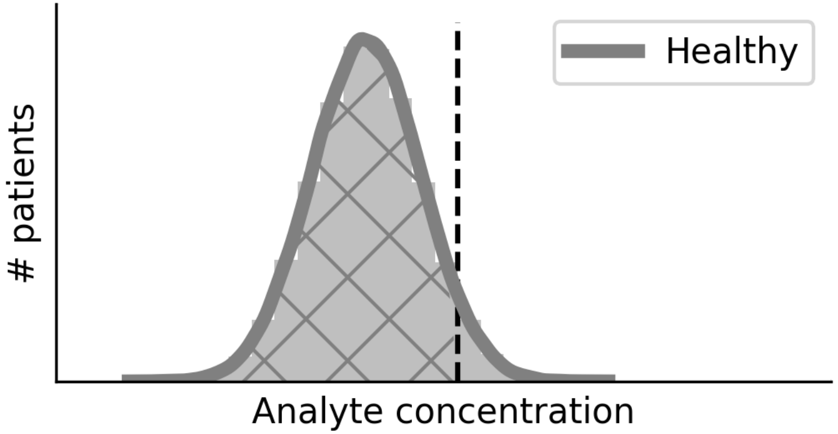


Does disease prevalence affect sensitivity?

A. Yes

B. No

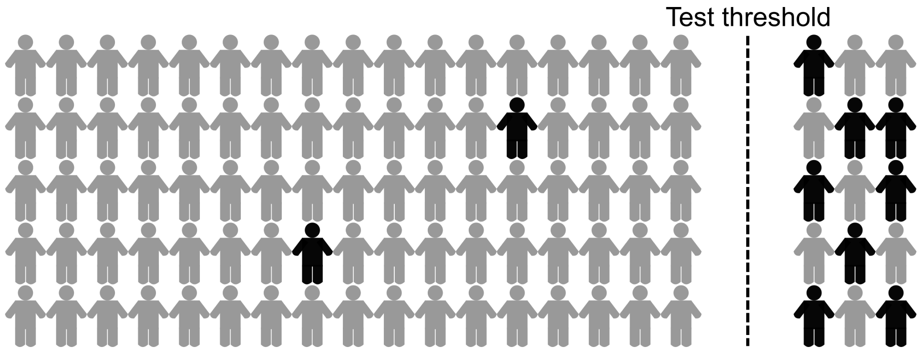
Specificity (Sp)

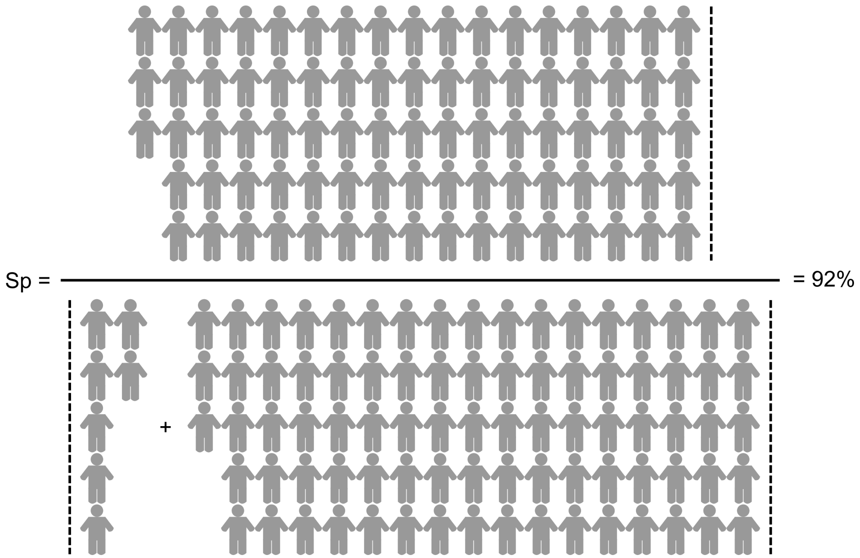


$$Sp = \frac{TN}{FP+TN}$$

1. Sp is the fraction of healthy individuals that do not test positive
2. Sp varies from zero to one
3. Sp increases with increasing threshold value

Specificity calculation example



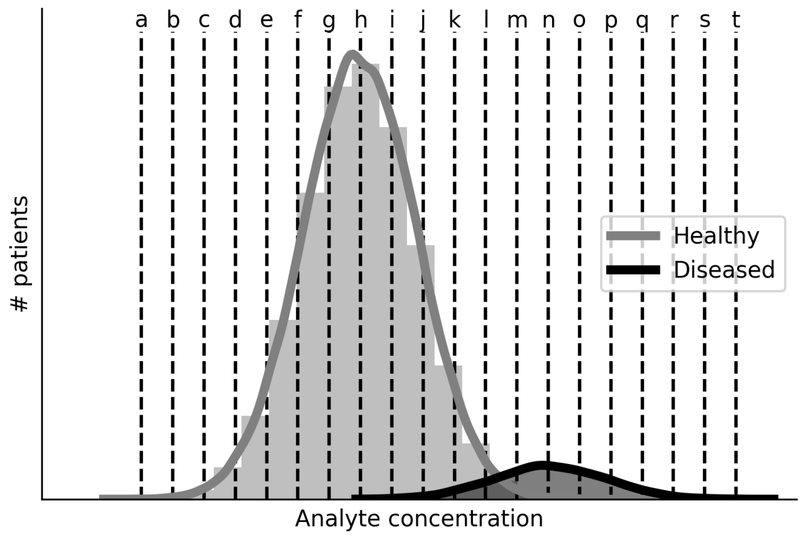


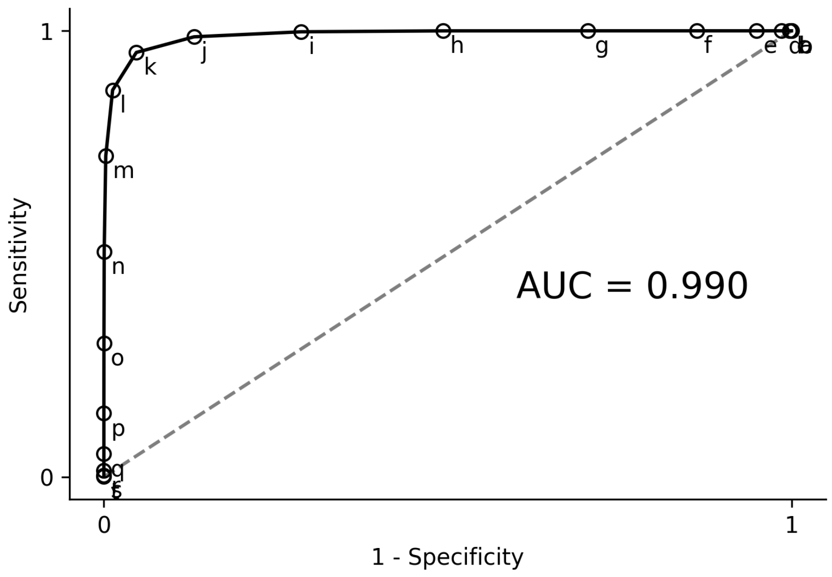
Does disease prevalence affect specificity?

A. Yes

B. No

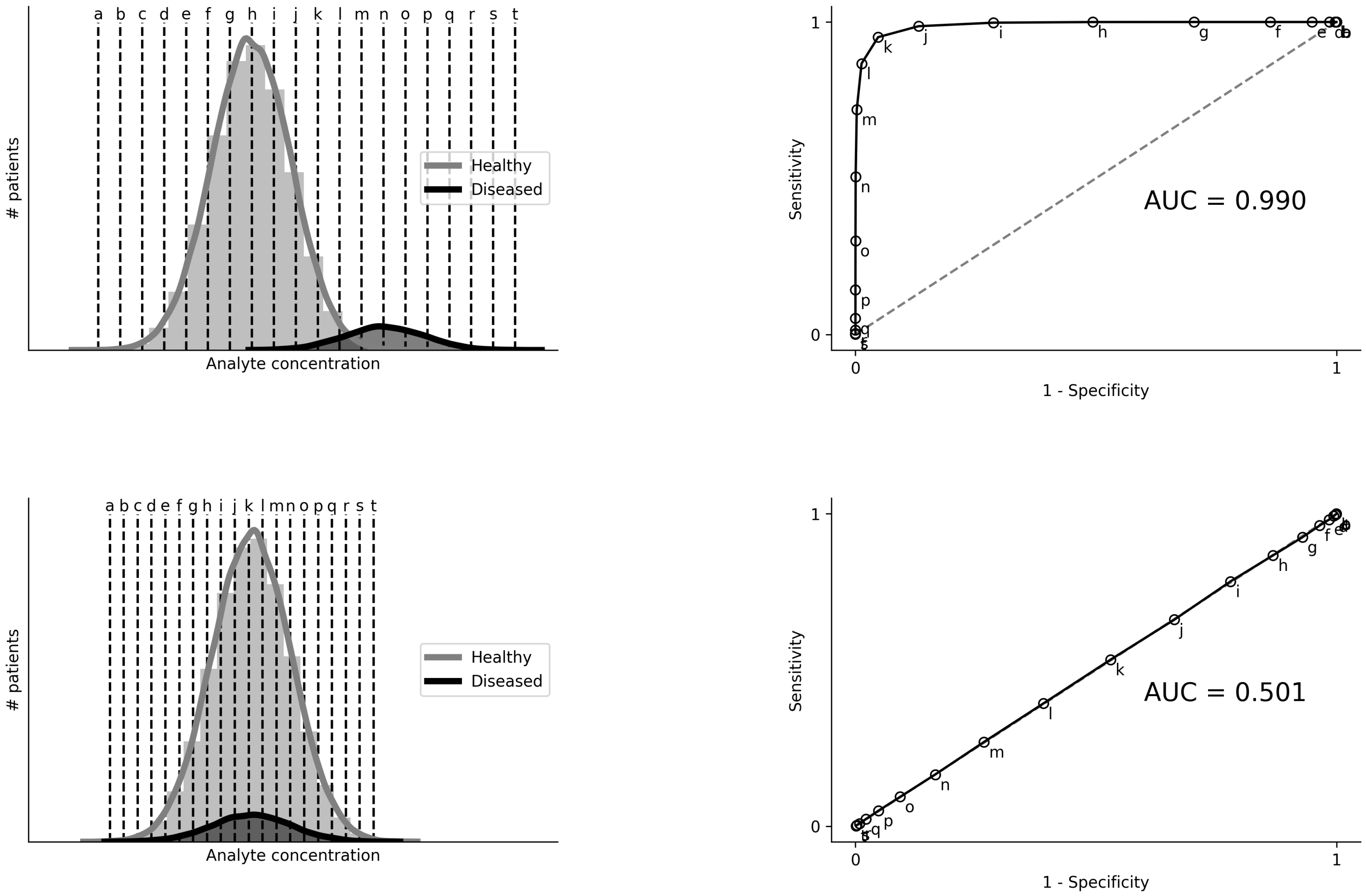
Receiver operating characteristic curves (ROCC)





Graphical plot summarizing the trade off between Se and Sp across varying thresholds

Area under the ROCC curve (AUROCC or C-statistic)



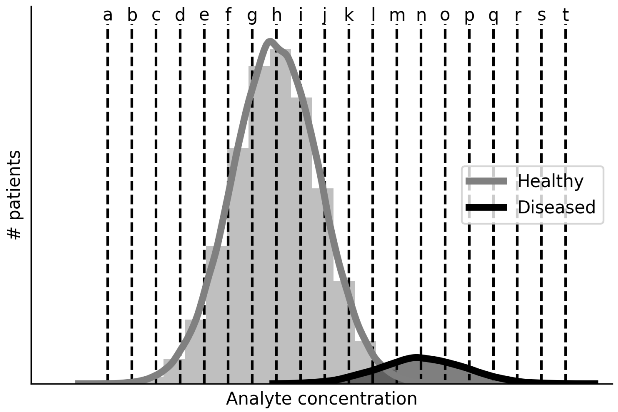
$$AUROCC = P([Analyte]_{d_i} > [Analyte]_{h_j})$$

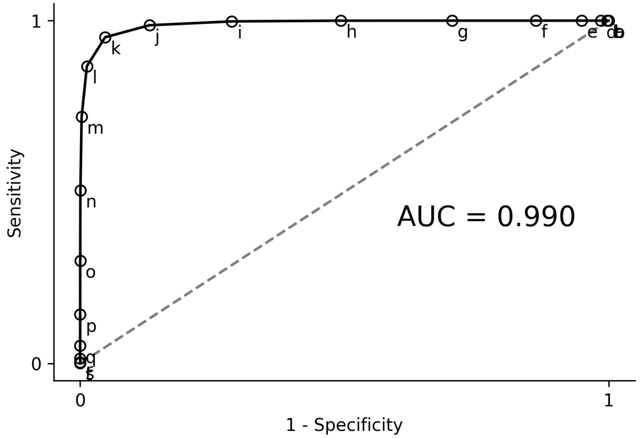
Does disease prevalence affect ROCC analysis?

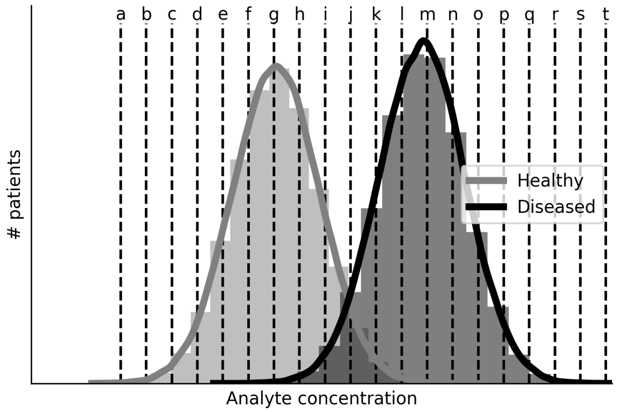
A. Yes

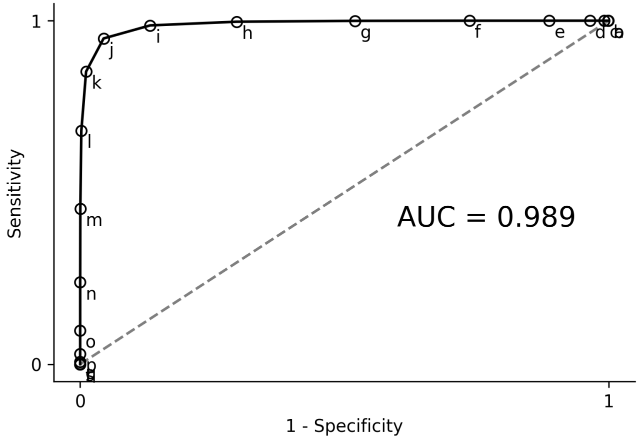
B. No

ROCC curves are not affected by prevalence



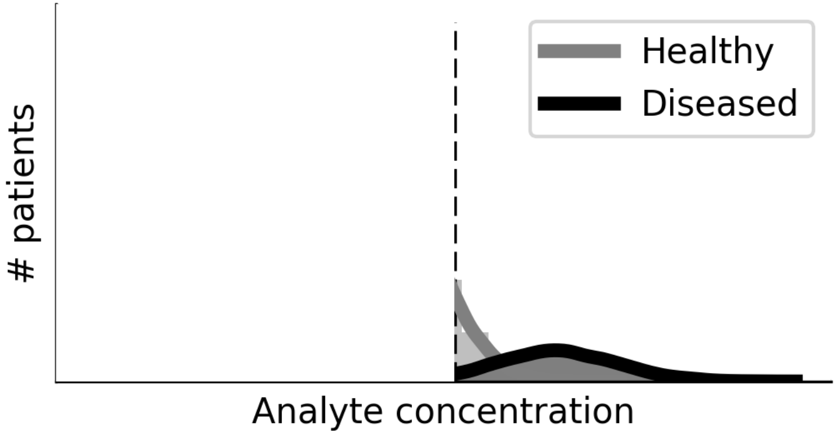






Positive and Negative Predictive Values

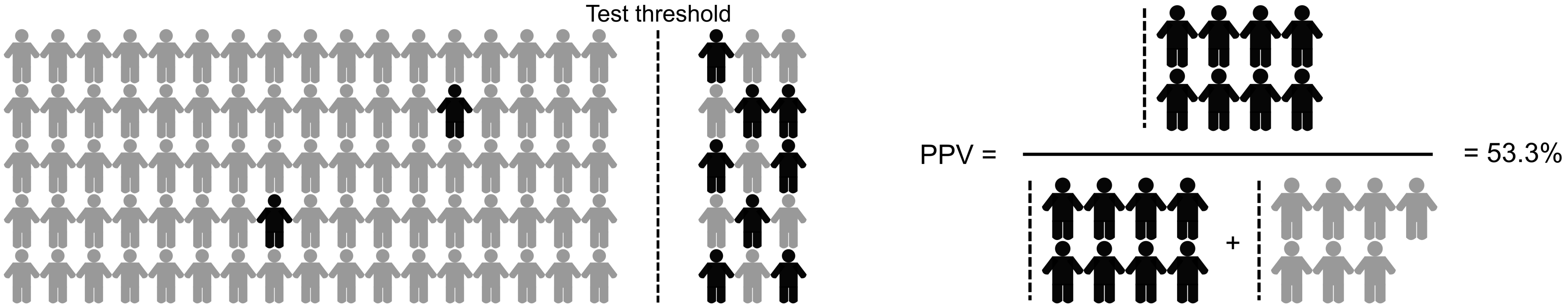
Positive Predictive Value (PPV)



$$PPV = \frac{TP}{TP+FP}$$

1. PPV is the fraction of individuals with a positive test result that have the disease
2. PPV varies from zero to one
3. PPV increases with increasing threshold value

PPV calculation example

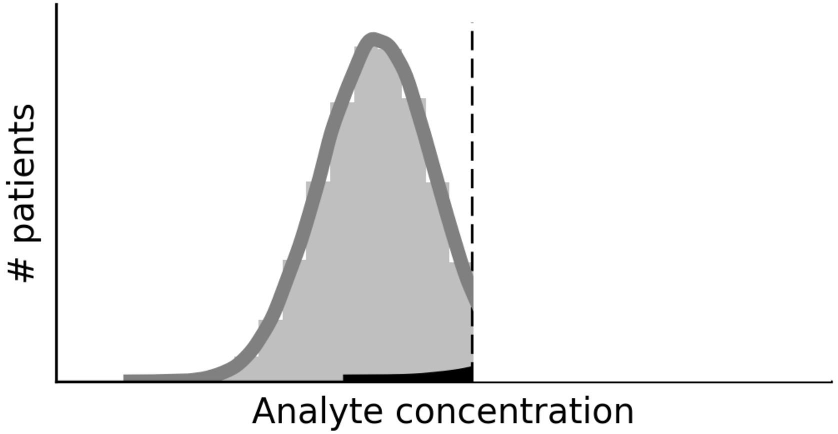


Does disease prevalence affect PPV?

A. Yes

B. No

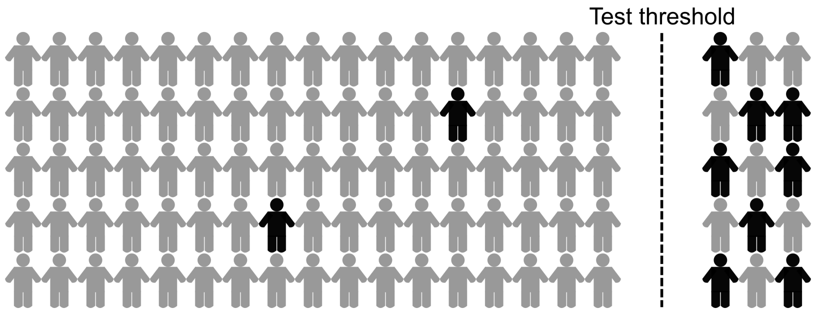
Negative Predictive Value (NPV)

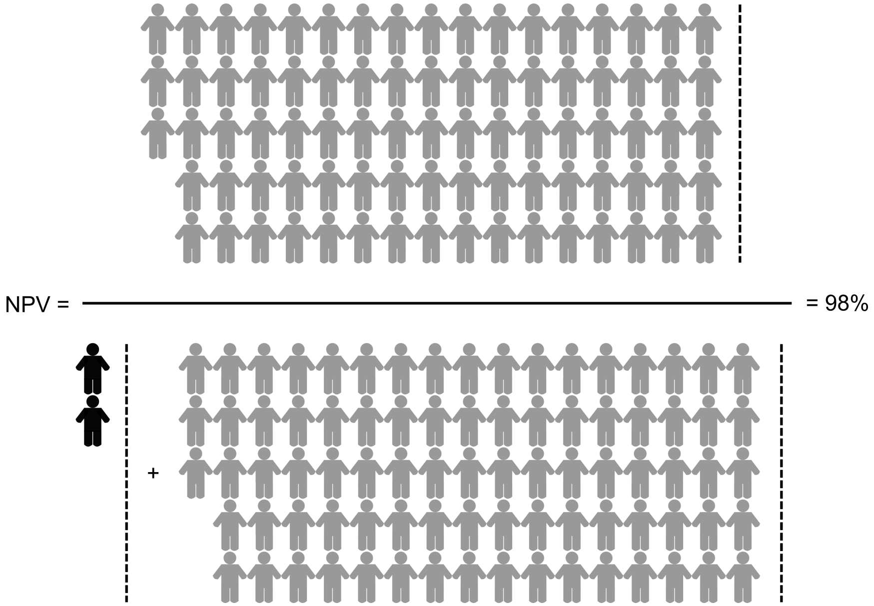


$$NPV = \frac{TN}{TN+FN}$$

1. NPV is the fraction of individuals with a negative test result that are healthy
2. NPV varies from zero to one
3. NPV increases with increasing threshold value

NPV calculation example





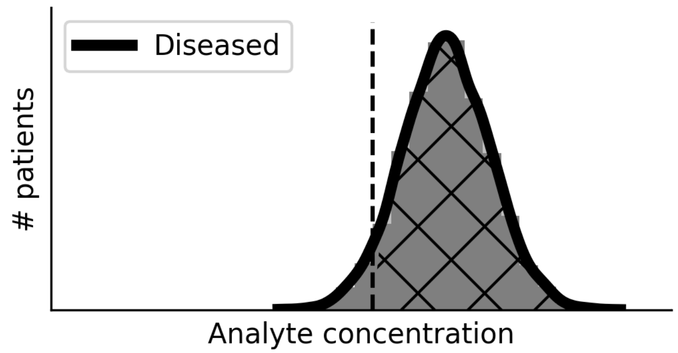
Does disease prevalence affect NPV?

A. Yes

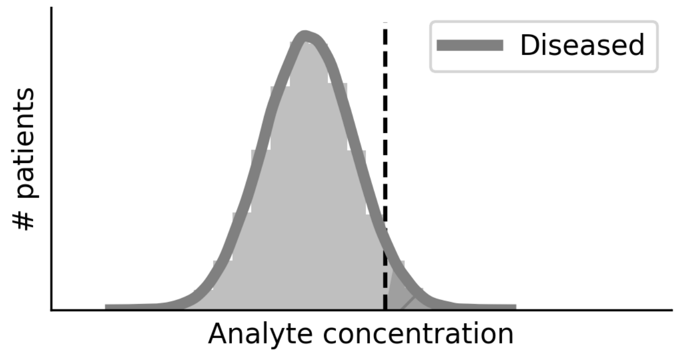
B. No

Likelihood Ratios and Diagnostic Odds Ratio

Positive Likelihood Ratio (LR^+)

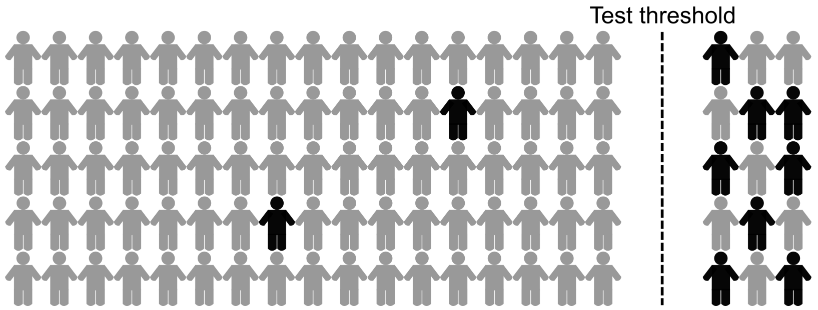


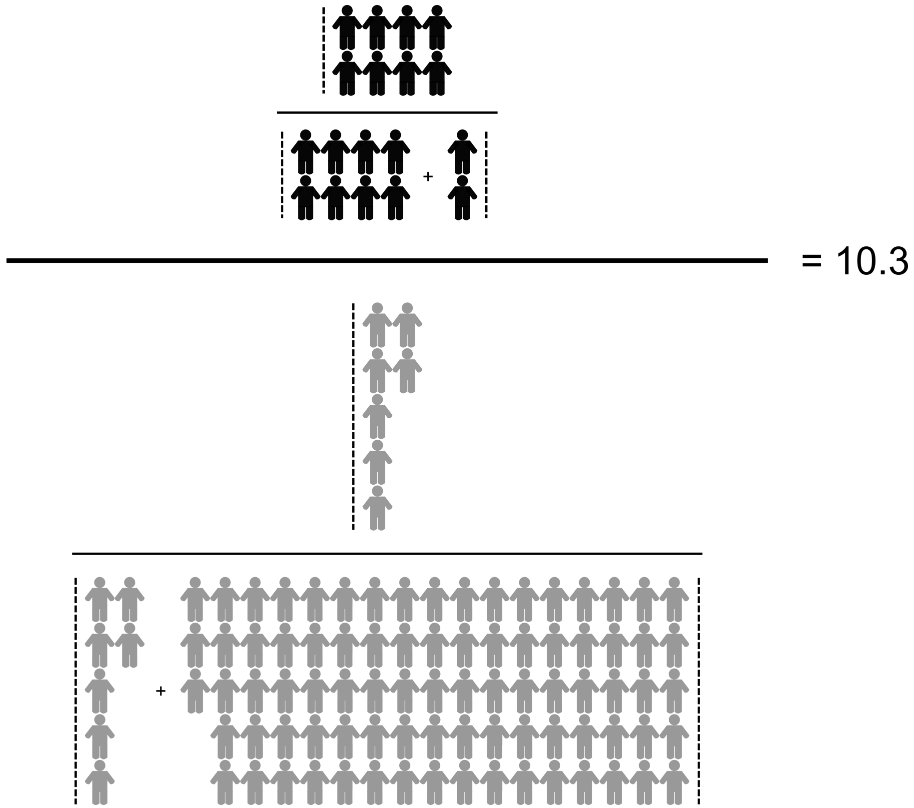
$$LR^+ = \frac{\frac{TP}{TP+FN}}{\frac{FP}{TN+FP}} = \frac{Se}{1-Sp}$$



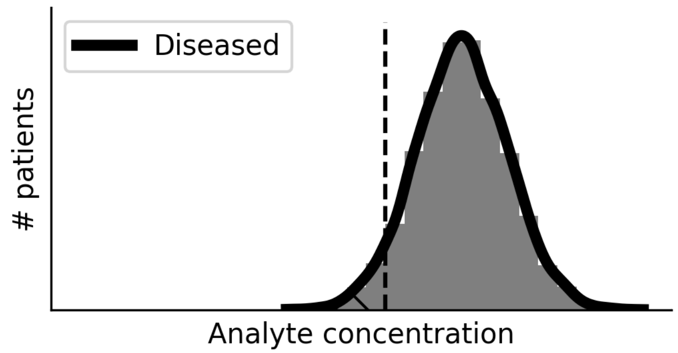
1. LR^+ is how many times more likely is a test positive result for diseased individual
2. LR^+ varies from zero to ∞

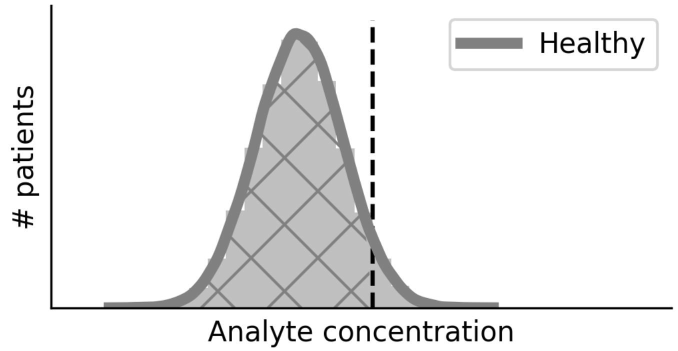
LR^+ calculation example





Negative Likelihood Ratio (LR^-)

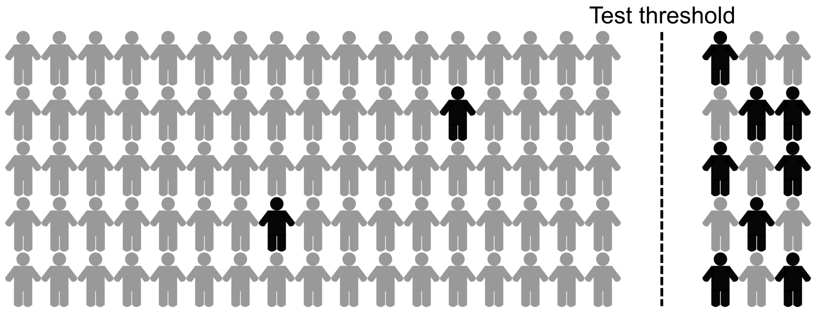


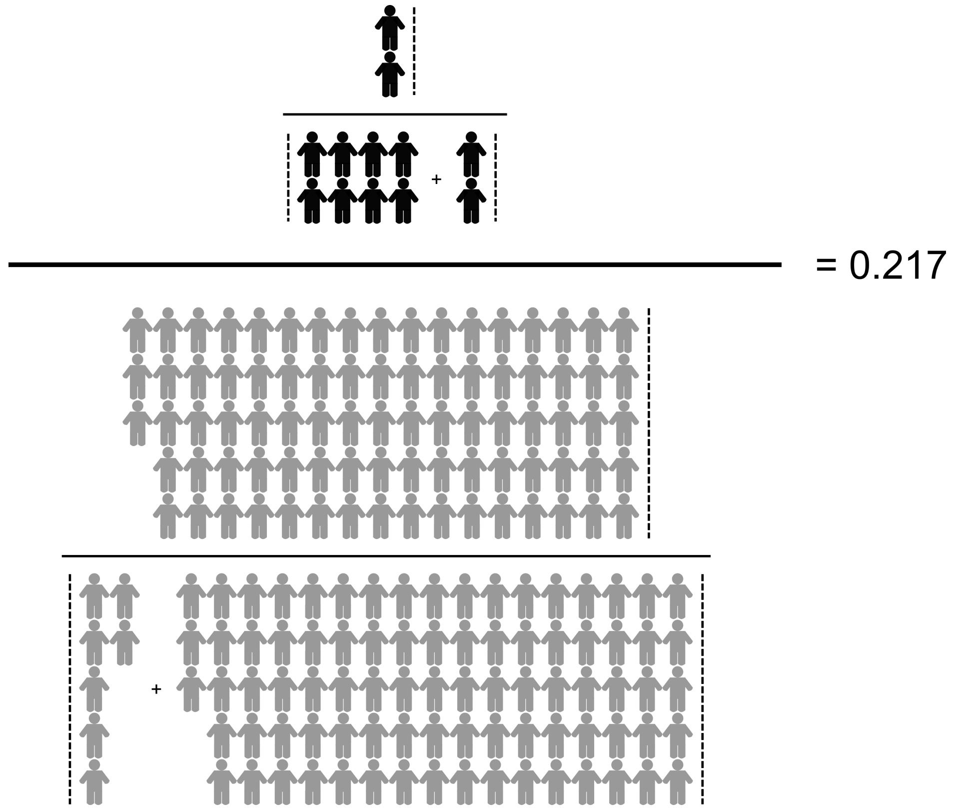


$$LR^- = \frac{\frac{FN}{TP+FN}}{\frac{TN}{TN+FP}} = \frac{1-Se}{Sp}$$

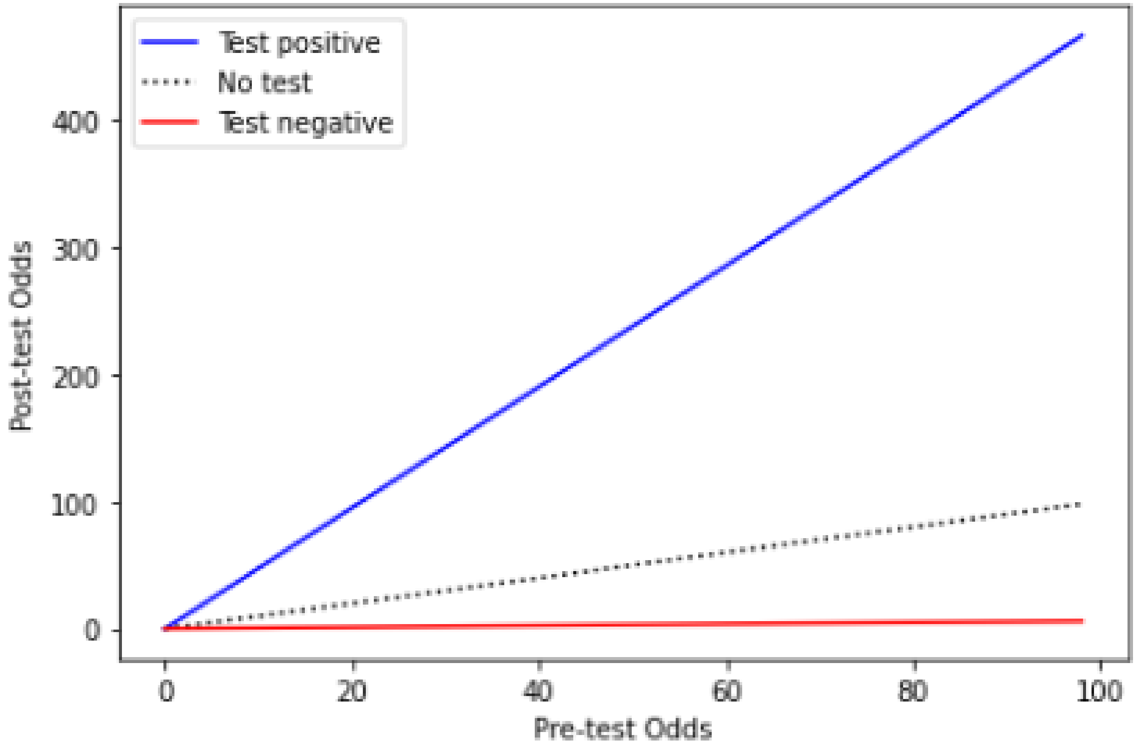
1. LR^- is how many times less likely is a negative test is for a diseased individual
2. LR^- varies from zero to ∞

LR^{-} calculation example





Likelihood ratios give a direct relationship between posttest and pretest odds



$$Odds^{Post|+} = LR^{+} * Odds^{Pre}$$

$$Odds^{Post|-} = LR^{-} * Odds^{Pre}$$

$$Odds(Disease) = \frac{p(Disease)}{1-p(Disease)}$$

*See handout for proof

Does disease prevalence affect LR^+ or LR^-?

A. Yes

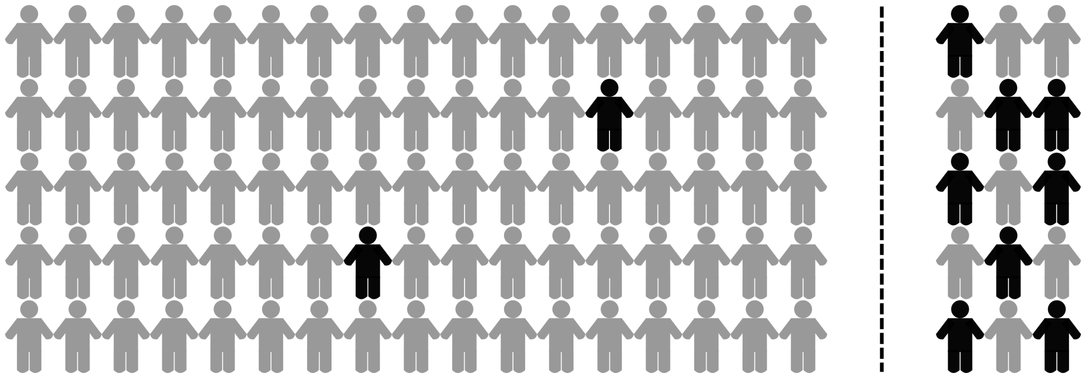
B. No

Diagnostic Odds Ratio (DOR)

$$DOR = \frac{LR^+}{LR^-} = \frac{\frac{\frac{TP}{TP+FN}}{\frac{FP}{FP+TN}}}{\frac{\frac{FN}{TP+FN}}{\frac{TN}{FP+TN}}} = \frac{TP * TN}{FP * FN}$$

1. DOR is a global measure of diagnostic accuracy
2. DOR varies from zero to ∞
   - $DOR < 1 \rightarrow$ Backwards Test
   - $DOR = 1 \rightarrow$ Useless Test
   - $1 < DOR < \infty \rightarrow$ Realistic test test
   - $DOR = \infty \rightarrow$ Perfect test

DOR calculation example



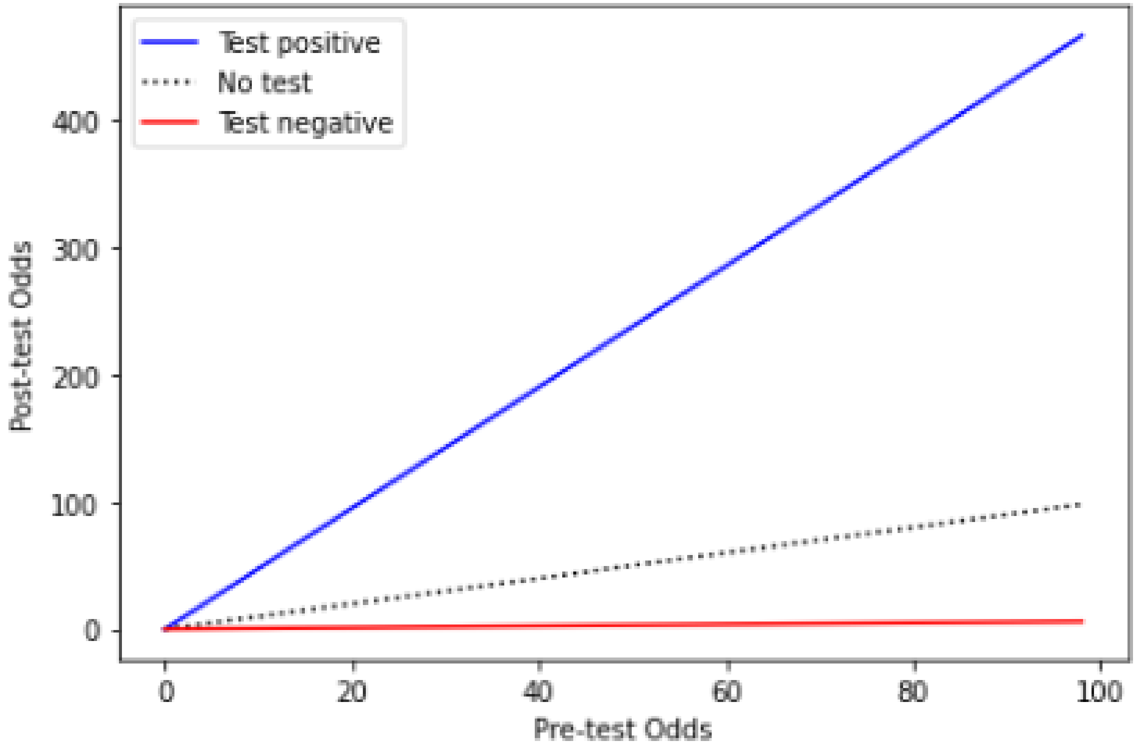
$$DOR = \frac{LR^{+}}{LR^{-}} = \frac{9.5}{0.22} = 43.18$$

Does disease prevalence affect DOR?

A. Yes

B. No

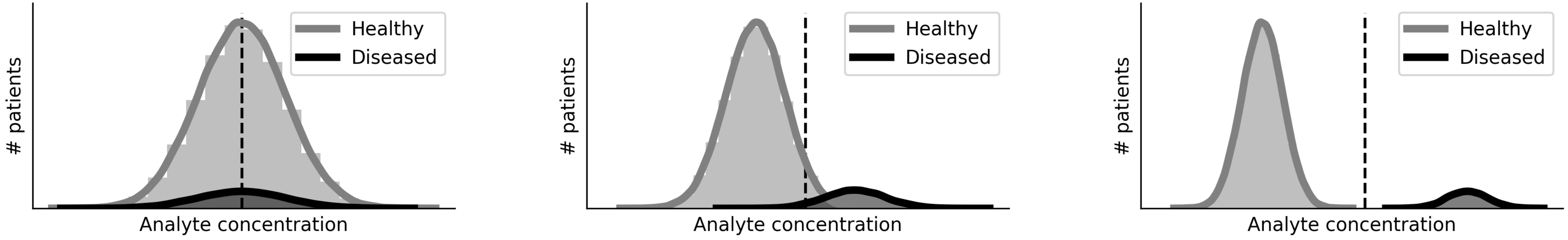
DOR gives a direct relationship between posttest odds associated with positive and negative test



$$Odds^{Post|+} = DOR * Odds^{Post|-}$$

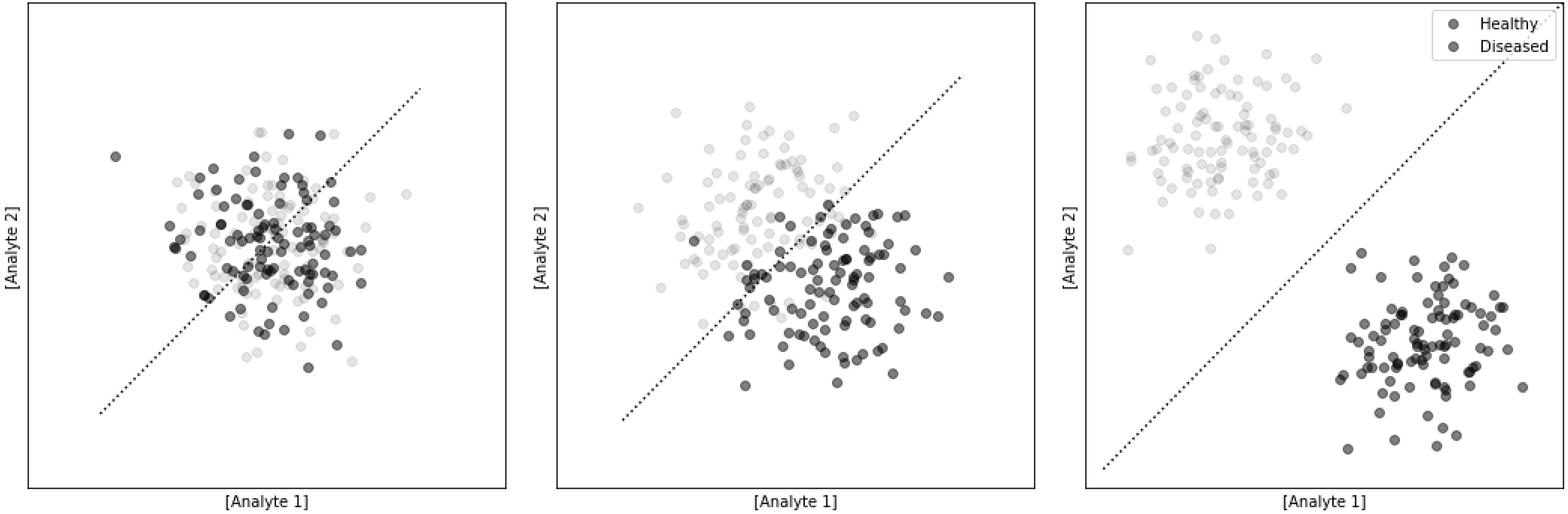
*See handout for proof

Conclusions



- Accuracy is the degree to which a boundary can be drawn to separate analyte values from healthy and diseased individuals
- Accuracy is a critical determinant of the usefullness of a test

Extending beyond one dimension



So many synonyms, so little time....

$$Sensitivity = recall = TPR$$

$$PPV = precision$$

$$etc. = etc. = etc.$$

*See your class handout for additional info

Metric	Trend with Increasing Prevalence
Sensitivity	No Change
Specificity	No Change
Area Under ROCC	No Change
Positive Predictive Value	Increase
Negative Predictive Value	Decrease
Positive Likelihood Ratio	No Change
Negative Likelihood Ratio	No Change
Diagnostic Odds Ratio	No Change