Sensitivity and specificity

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OUTLINE

- Measures of accuracy
- Positive and negative predictive value
- Limits of detection and how this impacts on sensitivity
- ROC curves
- Important measure in diagnostic tests (beyond sensitivity and specificity)

Sensitivity and specificity

Sensitivity =

Specificity =

Sensitivity and specificity

Sensitivity = proportion of true positives identified through the new test

Specificity =

	New Test pos	New Test neg	Total
Gold Standard pos	a	b	a+b
Gold Standard neg	c	d	c+d
Total	a+c	b+d	a+b+c+d

Sensitivity and specificity

Sensitivity = proportion of true positives identified through the new test

Specificity = proportion of true negatives identified through the new test

	New Test pos	New Test neg	Total
Gold Standard pos	a	b	a+b
Gold Standard neg	c	d	c+d
Total	a+c	b+d	a+b+c+d

Sensitivity and specificity

Sensitivity = proportion of true positives identified through the new test

=a/(a+b)

Specificity = proportion of true negatives identified through the new test

	New Test pos	New Test neg	Total
Gold Standard pos	a	b	a+b
Gold Standard neg	c	d	c+d
Total	a+c	b+d	a+b+c+d

Sensitivity and specificity

Sensitivity = proportion of true positives identified through the new test

=a/(a+b)

Specificity = proportion of true negatives identified through the new test

=d/(c+d)

	New Test pos	New Test neg	Total
Gold Standard pos	a	b	a+b
Gold Standard neg	c	d	c+d
Total	a+c	b+d	a+b+c+d

Sensitivity and PPV

Sensitivity =

=a/(a+b)

proportion of true positives identified through the new test

PPV =

=a/(a+c)

probability that somebody with a positive test has the disease

	New Test pos	New Test neg	Total
Gold Standard pos	a	b	a+b
Gold Standard neg	c	d	c+d
Total	a+c	b+d	a+b+c+d

Diagnostic test to diagnose breast cancer

Sensitivity = 80%
Specificity = 98%
Prevalence of breast cancer 10%

	New Test pos	New Test neg	Total
Breast cancer confirmed			
Breast cancer excluded			
Total			1000

Diagnostic test to diagnose breast cancer

Sensitivity = 80%
Specificity = 98%
Prevalence of breast cancer 10%

	New Test pos	New Test neg	Total
Breast cancer confirmed			100
Breast cancer excluded			
Total			1000

Diagnostic test to diagnose breast cancer

Sensitivity = 80%
Specificity = 98%
Prevalence of breast cancer 10%

	New Test pos	New Test neg	Total
Breast cancer confirmed			100
Breast cancer excluded			900
Total			1000

Diagnostic test to diagnose breast cancer

Sensitivity = 80%
Specificity = 98%
Prevalence of breast cancer 10%

	New Test pos	New Test neg	Total
Breast cancer confirmed	80	20	100
Breast cancer excluded			900
Total			1000

Diagnostic test to diagnose breast cancer

Sensitivity = 80%
Specificity = 98%
Prevalence of breast cancer 10%

	New Test pos	New Test neg	Total
Breast cancer confirmed	80	20	100
Breast cancer excluded	18	882	900
Total			1000

Diagnostic test to diagnose breast cancer

Sensitivity = 80%
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Prevalence of breast cancer 10%

What is the positive predictive value?

	New Test pos	New Test neg	Total
Breast cancer confirmed	80	20	100
Breast cancer excluded	18	882	900
Total	98	902	1000

Diagnostic test to diagnose breast cancer

Sensitivity = 80%
Specificity = 98%
Prevalence of breast cancer 10%

	New Test pos	New Test neg	Total
Breast cancer confirmed	**80**	20	100
Breast cancer excluded	18	882	900
Total	**98**	902	1000

PPV=80/98=82%

Diagnostic test to diagnose breast cancer

Sensitivity = 80%
Specificity = 98%
Prevalence of breast cancer 1%

	New Test pos	New Test neg	Total
Breast cancer confirmed			
Breast cancer excluded			
Total			1000

Diagnostic test to diagnose breast cancer

Sensitivity = 80%
Specificity = 98%
Prevalence of breast cancer 1%

	New Test pos	New Test neg	Total
Breast cancer confirmed	8	2	10
Breast cancer excluded	20	970	990
Total	28	972	1000

PPV=8/28=29%

Sensitivity, specificity, prevalence, PPV

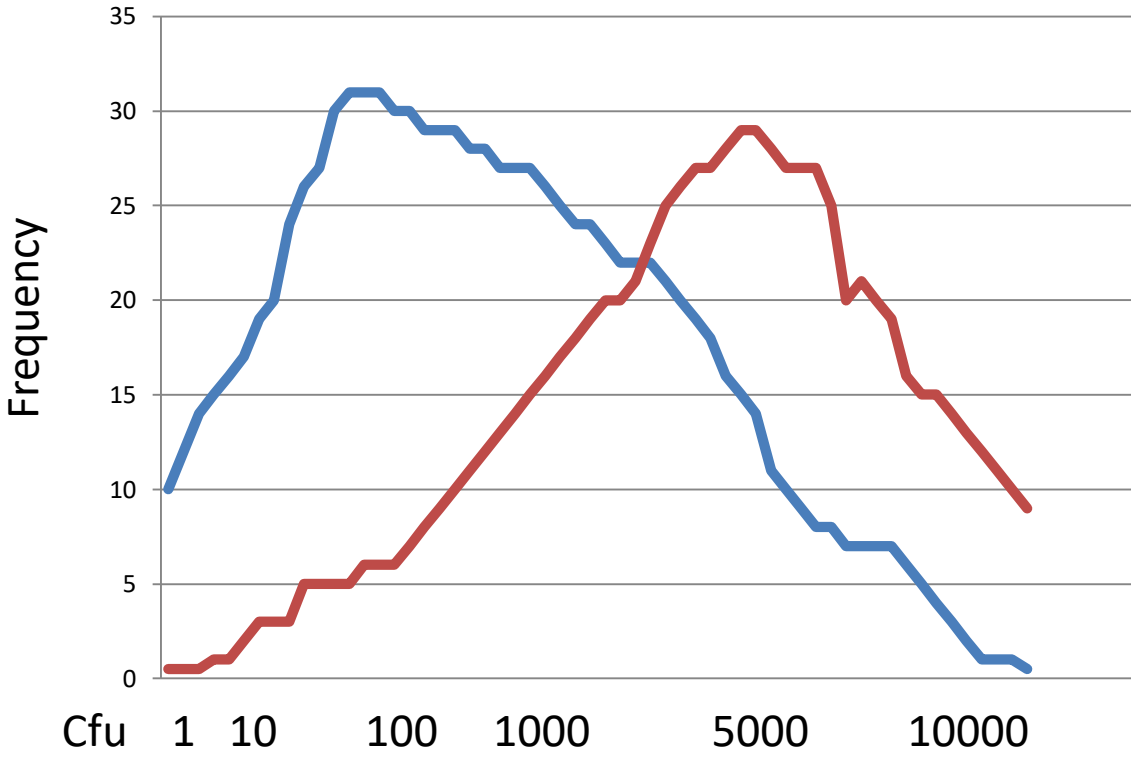
	low sensitivity			high sensitivity+specificity			low specificity		
Sens	80%	80%	80%	99%	99%	99%	99%	99%	99%
Spe	98%	98%	98%	98%	98%	98%	90%	90%	90%
Prev	10%	1%	0.5%	10%	1%	0.5%	10%	1%	0.5%
PPV	82%	29%	17%	85%	33%	20%	52%	9%	5%

Limits of detection

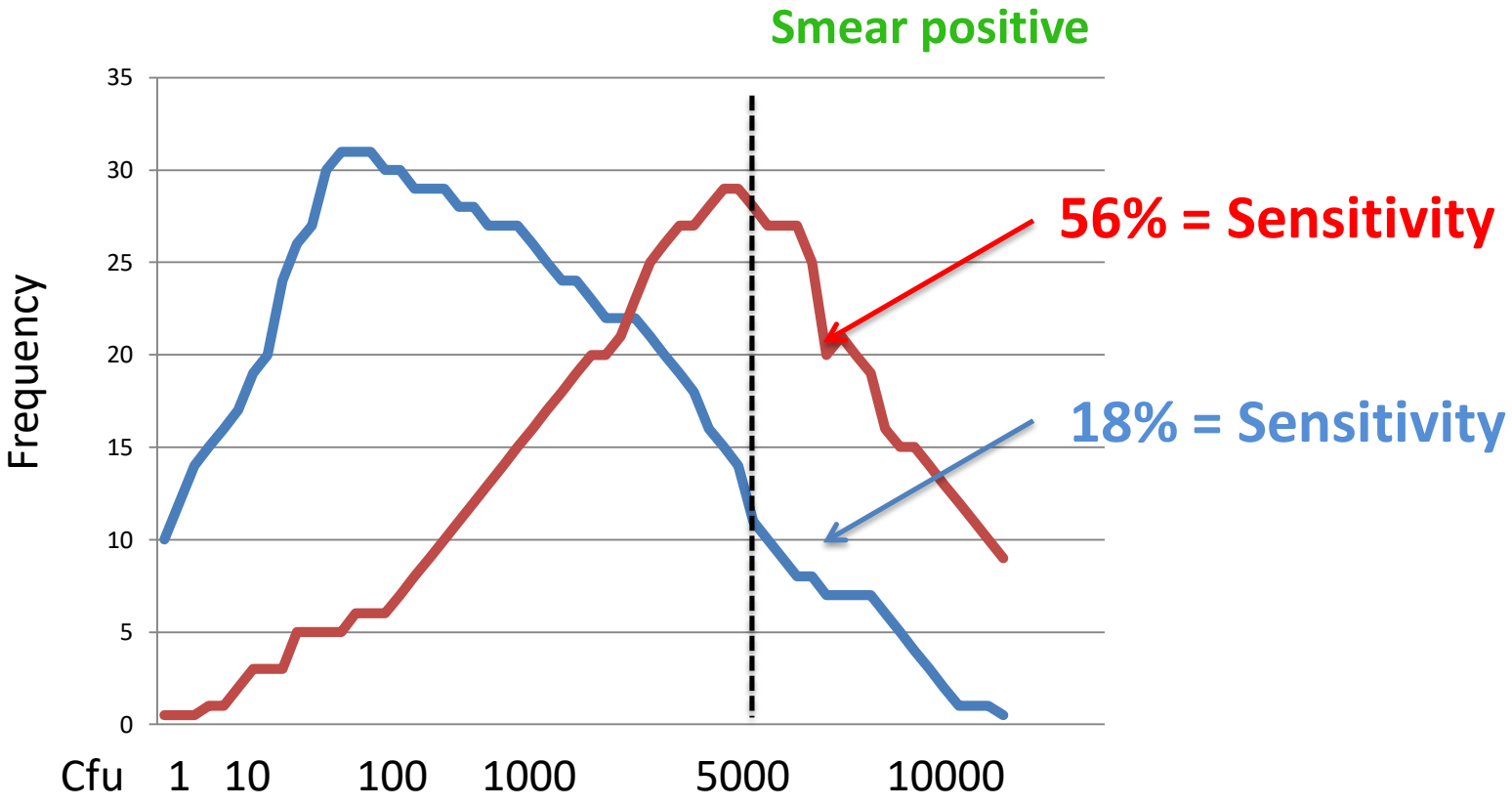
	Mycobacterial culture	1-50 cfu/ml
	NAT (e.g. Xpert MTB/RIF)	130 cfu/ml
	Smear microscopy	5 000 – 10 000 cfu/ml

Example: TB

Bacteria burden in a population

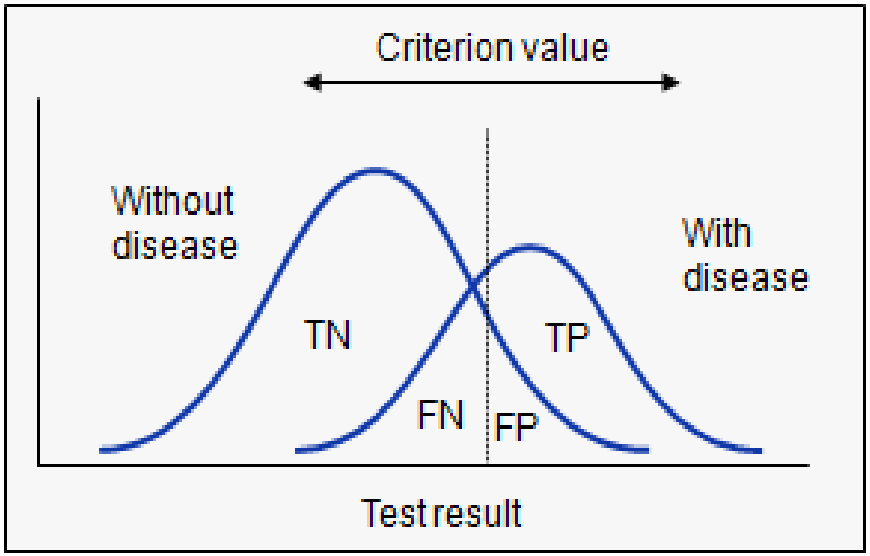


Bacteria burden in a population



ROC curves for continuous measurements with a cut off

- True positive rate (sensitivity) is plotted in function of the false positive rate (100-specificity) for different cut-off points of a parameter.
- Each point on the ROC curve represents a sensitivity/specificity pair corresponding to a particular decision threshold.
- The area under the ROC curve (AUC) is a measure of how well a parameter can distinguish between two diagnostic groups (diseased/normal).



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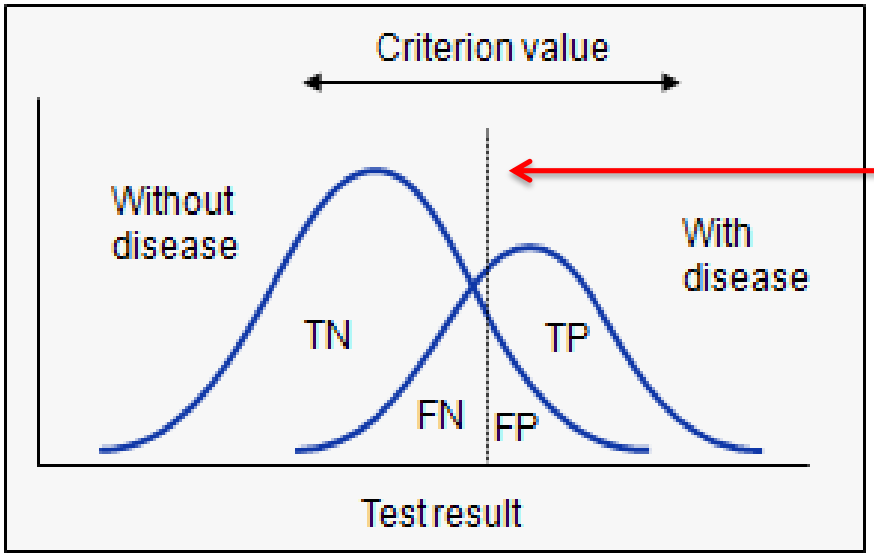
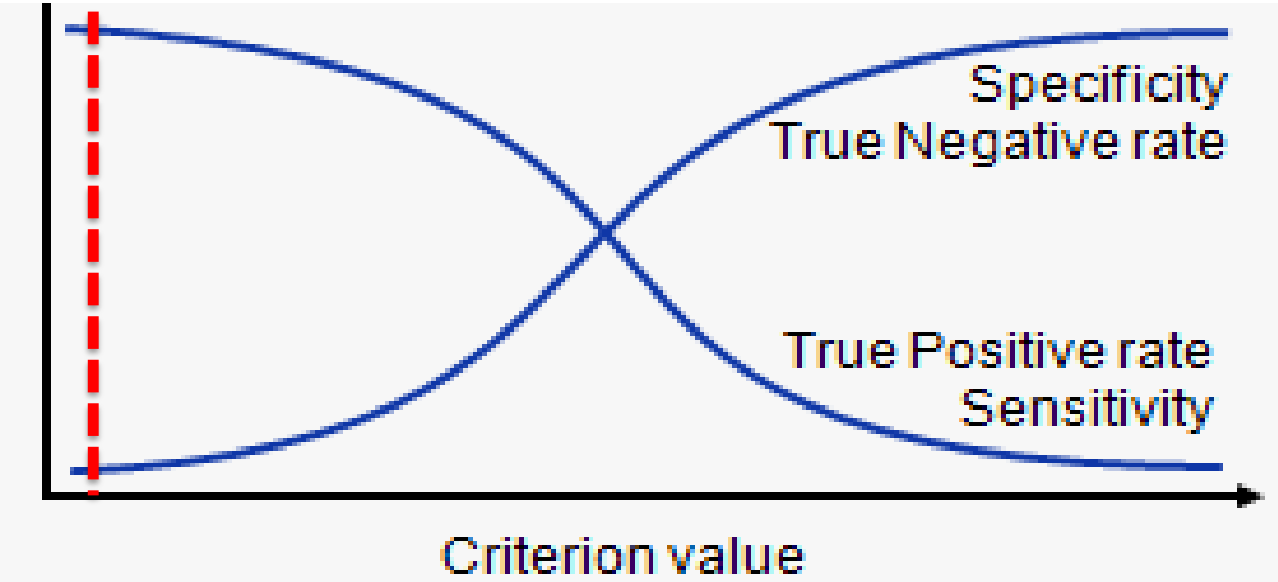


What happens to sensitivity and specificity if we move the threshold criterion to the right?

ROC curves

high sensitivity
high true pos rate
low specificity
low true negative rate

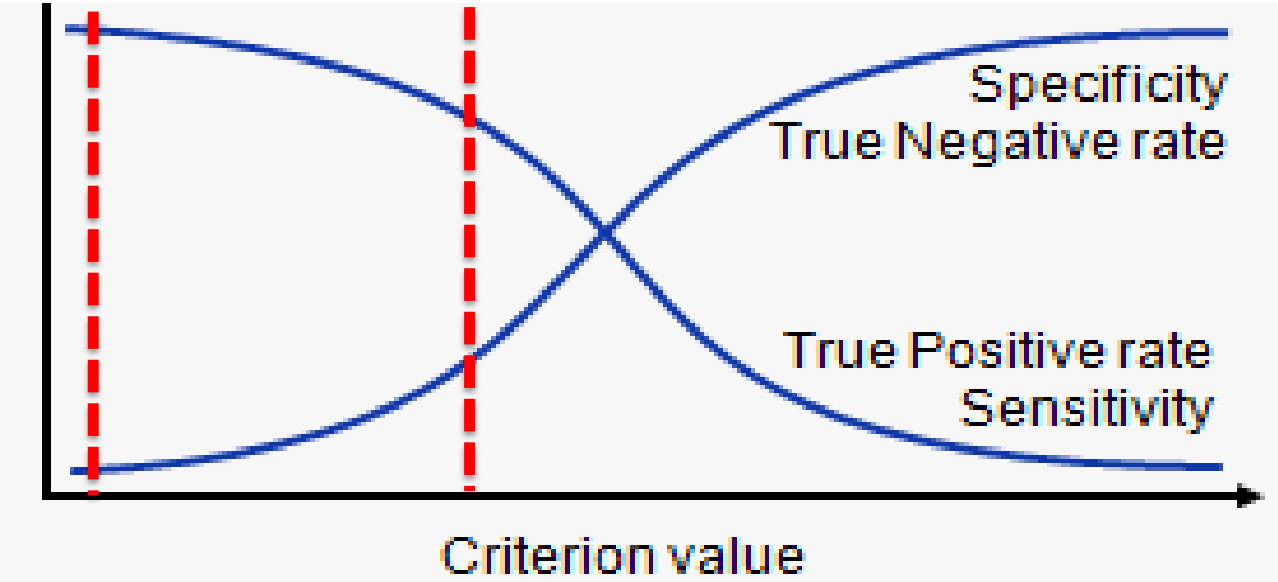


Systolic BP 80

ROC curves

high sensitivity
high true pos rate
low specificity
low true negative rate

decreasing sensitivity
increasing specificity



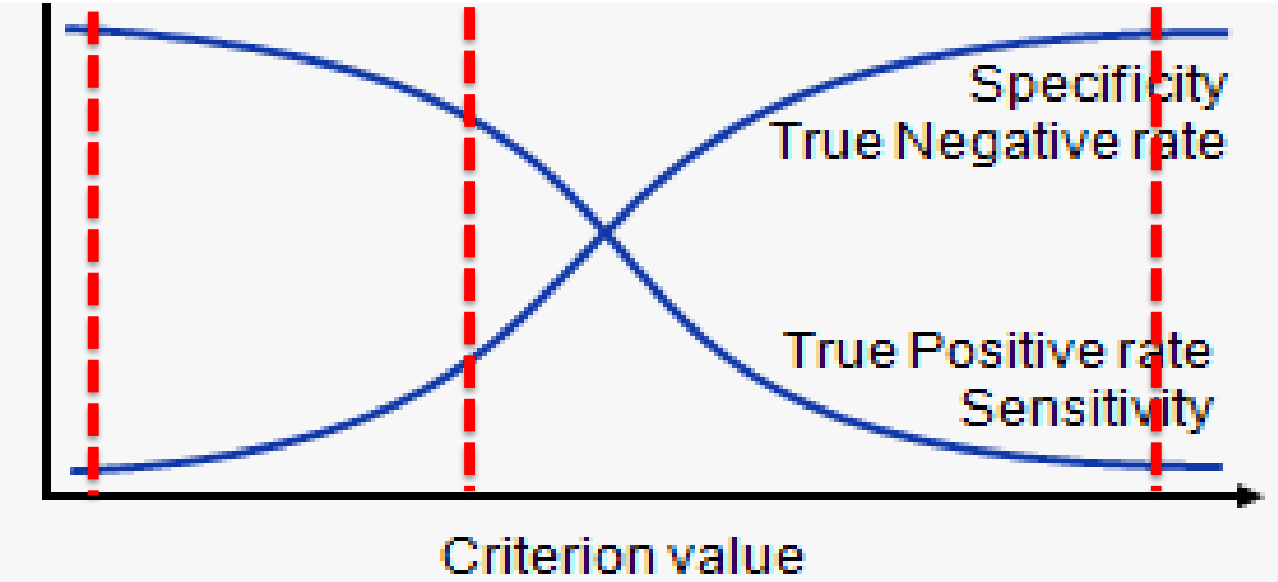
Systolic BP 80 140

ROC curves

high sensitivity
high true pos rate
low specificity
low true negative rate

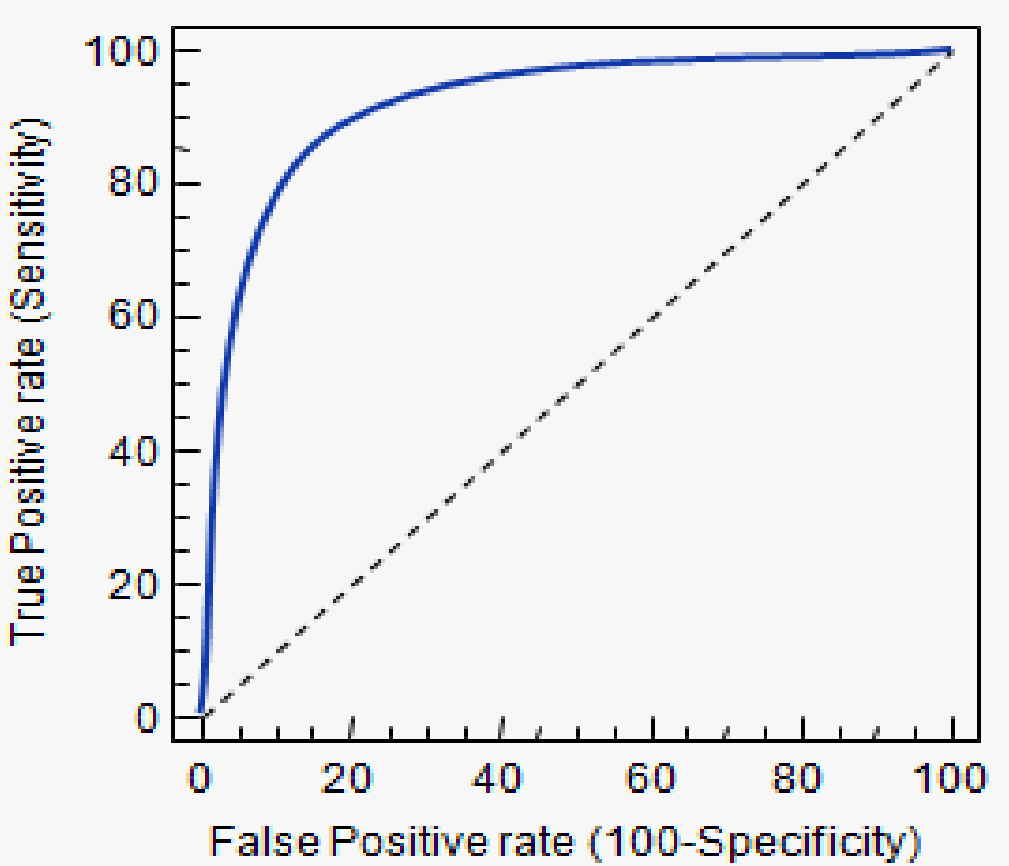
decreasing sensitivity
increasing specificity

low sensitivity
low true pos rate
high specificity
high true negative rate



Systolic BP 80 140 200

ROC curves



- Each point on the ROC curve represents a sensitivity/specificity pair corresponding to a particular decision threshold.
- A test with perfect discrimination (no overlap in the two distributions) has a ROC curve that passes through the upper left corner (100% sensitivity, 100% specificity).

Repeatability vs reproducibility

Repeatability is measured by performing a test repeatedly over a short period of time at the same location; using the same measurement procedure/ observer/measuring instrument/under the same conditions

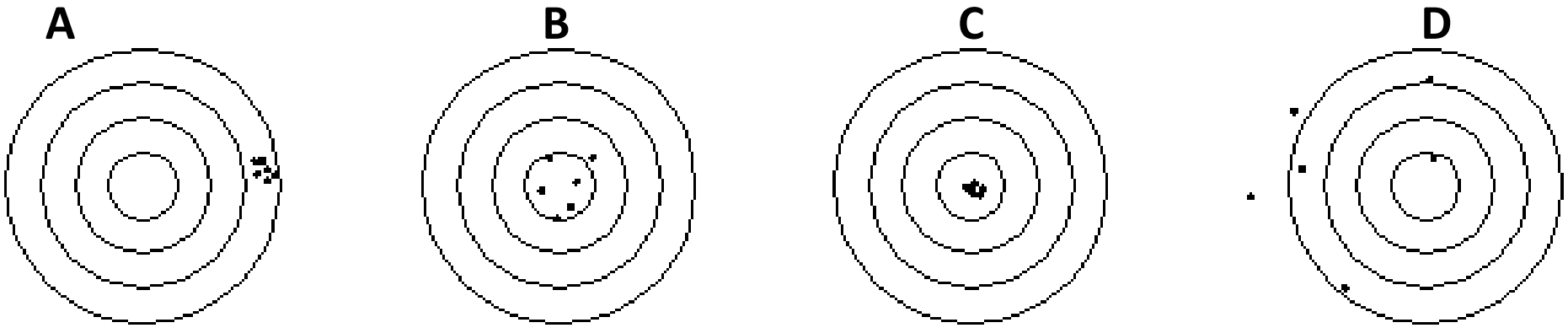
repeatability coefficient is a measurement of precision, which denotes the absolute difference between a pair of repeated test results.

Reproducibility is the degree of agreement between the results of experiments conducted by different individuals, at different locations, with different instruments.

Accuracy vs precision

Accuracy = to how close a gage's measurements are to the true value.

Precision = how close measurements are to each other.



Accurate or precise or both or none?

Summary

- Positive predictive values are mainly influenced by prevalence of the condition and specificity of the test
- Limits of detection are particularly important in infectious diseases resulting in different sensitivity for different populations
- Cut off of criterion levels influence sensitivity and specificity
- Other important parameters when assessing diagnostic tests are repeatability, reproducibility, accuracy and precision