A Patient with Sore Throat

A mother brings her 12-year-old daughter in to see you because the child has a sore throat.
What are your concerns?
Your examination finds a fever (103.1°F), tonsillar membranes, and anterior cervical lymph nodes that are enlarged and tender. There is no cough or history of cough. The girl’s brother had the same syndrome 3 days ago, and you cultured Group A beta-hemolytic streptococci from his throat.
What are your options? What do you do?

Another Patient with Sore Throat

Another mother brings her 12-year-old daughter in to see you because the child has a sore throat.
Your examination finds no fever (97.2°F), no tonsillar membranes, and no anterior cervical lymph nodes. The girl coughs continuously during your examination. The girl’s brother had the same syndrome 3 days ago, and your culture of his throat did not find any pathogenic bacteria.
What do you do?
The Threshold Approach to Medical Decision Making

<table>
<thead>
<tr>
<th>Probability of Disease</th>
<th>No Test, No Treatment</th>
<th>Test, Use Test Result to Decide about Treatment</th>
<th>No Test, Treat</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>TT</td>
<td>TTT</td>
<td>TTT</td>
</tr>
</tbody>
</table>

Test Threshold

Test-Treatment Threshold

Wistar discoveries have led to the development of vaccines for rabies and rubella, the identification of genes associated with breast, lung, and prostate cancer, and the development of monoclonal antibodies. The Wistar Institute is an independent research center that has close working relationships with the University of Pennsylvania, Children’s Hospital of Philadelphia, and other organizations.
How do you decide how good a diagnostic test is?

What are the operating characteristics of a diagnostic test?

### Diagnostic Tests with Dichotomous Outcomes

**The Standard 2 by 2 Table**

<table>
<thead>
<tr>
<th></th>
<th>Disease Present</th>
<th>Disease Absent</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test Result</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Positive</td>
<td>True Positive</td>
<td>False Positive</td>
<td>TP + FP</td>
</tr>
<tr>
<td>Negative</td>
<td>False Negative</td>
<td>True Negative</td>
<td>FN + TN</td>
</tr>
<tr>
<td>Total</td>
<td>TP + FN</td>
<td>FP + TN</td>
<td></td>
</tr>
</tbody>
</table>

### Operating Characteristics 1

<table>
<thead>
<tr>
<th></th>
<th>Disease Present</th>
<th>Disease Absent</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test Result</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Positive</td>
<td>TP</td>
<td>FP</td>
<td>TP + FP</td>
</tr>
<tr>
<td>Negative</td>
<td>FN</td>
<td>TN</td>
<td>FN + TN</td>
</tr>
<tr>
<td>Total</td>
<td>TP + FN</td>
<td>FP + TN</td>
<td></td>
</tr>
</tbody>
</table>

Sensitivity = \[ \frac{TP}{TP + FN} \]

Specificity = \[ \frac{TN}{FP + TN} \]
An Example

<table>
<thead>
<tr>
<th></th>
<th>Disease Present</th>
<th>Disease Absent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test Result</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Positive</td>
<td>97</td>
<td>5</td>
</tr>
<tr>
<td>Negative</td>
<td>3</td>
<td>95</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

Sensitivity = \frac{97}{100} = 0.97

Specificity = \frac{95}{100} = 0.95
Answer: **Sensitivity**

**Question 1**
- What is the probability that the patient will have disease when the test result is positive?

**Question 2**
- What is the probability that the test result will be positive when the patient has disease?

Answer: **Specificity**

**Question 1**
- What is the probability that the patient will not have disease when the test result is negative?

**Question 2**
- What is the probability that the test result will be negative when the patient does not have disease?

---

**Operating Characteristics**

<table>
<thead>
<tr>
<th></th>
<th>Disease Present</th>
<th>Disease Absent</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test Result Positive</td>
<td>TP, FP</td>
<td>TP + FP</td>
<td></td>
</tr>
<tr>
<td>Test Result Negative</td>
<td>FN, TN</td>
<td>FN + TN</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>TP + FN</td>
<td>FP + TN</td>
<td></td>
</tr>
</tbody>
</table>

Negative Predictive Value (NPV) = \( \frac{TN}{TN + FN} \)

Positive Predictive Value (PPV) = \( \frac{TP}{TP + FP} \)
### Compare Sensitivity and Specificity

<table>
<thead>
<tr>
<th></th>
<th>Disease Present</th>
<th>Disease Absent</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Test Result</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Positive</td>
<td>TP</td>
<td>FP</td>
<td>TP + FP</td>
</tr>
<tr>
<td>Negative</td>
<td>FN</td>
<td>TN</td>
<td>FN + TN</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>TP + FN</td>
<td>FP + TN</td>
<td></td>
</tr>
</tbody>
</table>

**Positive Predictive Value (PPV)**

\[
\text{PPV} = \frac{TP}{TP + FP} \times \frac{TP + FN}{All \text{ Positives}}
\]

**Negative Predictive Value (NPV)**

\[
\text{NPV} = \frac{TN}{TN + FN} \times \frac{FN + TN}{All \text{ Negatives}}
\]

### An Example

<table>
<thead>
<tr>
<th></th>
<th>Disease Present</th>
<th>Disease Absent</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Test Result</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Positive</td>
<td>97</td>
<td>5</td>
<td>102</td>
</tr>
<tr>
<td>Negative</td>
<td>3</td>
<td>95</td>
<td>98</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>100</td>
<td>100</td>
<td>200</td>
</tr>
</tbody>
</table>

\[
\text{PPV} = \frac{97}{102} \times \frac{102}{All \text{ Positives}} = 0.95
\]

\[
\text{NPV} = \frac{95}{98} \times \frac{98}{All \text{ Negatives}} = 0.97
\]

### Another Example: Screening

<table>
<thead>
<tr>
<th></th>
<th>Disease Present</th>
<th>Disease Absent</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Test Result</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Positive</td>
<td>97</td>
<td>4,995</td>
<td>5,092</td>
</tr>
<tr>
<td>Negative</td>
<td>3</td>
<td>94,905</td>
<td>94,908</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>100</td>
<td>99,900</td>
<td>100,000</td>
</tr>
</tbody>
</table>

\[
\text{PPV} = \frac{97}{5,092} \times \frac{5,092}{All \text{ Positives}} = 0.02
\]

\[
\text{NPV} = \frac{94,905}{94,908} \times \frac{94,908}{All \text{ Negatives}} = 0.99
\]
Why did the positive predictive value change so much?

Is it good or bad that predictive values change when the prevalence of disease changes?
LII. An Essay towards solving a Problem in the Doctrine of Chances. By the late Rev. Mr. Bayes, F. R. S. communicated by Mr. Price, in a Letter to John Canton, A. M. F. R. S.

Dear Sir,

Read Dec. 29. I now send you an essay which I have found among the papers of our deceased friend Mr. Bayes, and which, in my opinion, has great merit, and well deserves to be preserved. Experimental philosophy, you will find, is nearly interested in the subject of it; and I think this account there seems to be particular reason for thinking that a communication of it to the Royal Society cannot be improper.

He had, you know, the honour of being a member of that illustrious Society, and was much esteemed by many in it as a very able mathematician. In an introduction which he has writ to this Essay, he says, that his design at first in thinking on the subject of it
Compare

Sensitivity and Specificity
- Have the same numerators as predictive values, but the denominators are disease status
- Are calculated vertically in the standard 2by2 table
- Do not change with disease prevalence or disease probability
- Answer questions that are clinically irrelevant

Predictive values
- Have the same numerators as sensitivity and specificity, but the denominators are test results
- Are calculated horizontally in the standard 2by2 table
- Do change with disease prevalence and disease probability
- Answer questions that are clinically relevant

If sensitivity and specificity answer clinically irrelevant questions, why are they so often used to describe the operating characteristics of diagnostic tests?

Does a positive test result mean the patient has disease? Does a negative test result mean the patient does not have disease? What do test results mean?
A Refinement to The Threshold Approach for Medical Decision Making

<table>
<thead>
<tr>
<th>Probability of Disease</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
</tr>
<tr>
<td>1</td>
</tr>
</tbody>
</table>

- No More Tests, No Treatment
- Test, Use Test Result to Revise the Probability of Disease
- Continue Testing until a Threshold is Crossed
- No More Tests, Treat

TT
Test Threshold

TTT
Test-Treatment Threshold

What the first part of this course is about.

How to revise the probability of disease after the test result is known.

What the first part of this course is really about.

How to calculate predictive values.
Definitions

• The “prior probability” of disease and the “pretest probability” of disease are the probability of disease before doing a diagnostic test.
• The “posterior probability” of disease and the “post-test probability” of disease are the revised probability of disease after doing a diagnostic test and combining information from the test result with the pretest probability of disease.

Testing Spinal Fluid for Alzheimer’s Disease

Cerebrospinal Fluid Biomarker Signature in Alzheimer’s Disease.
Ann Neurol 2009;65:403–413

Leslie M. Shaw, PhD*, Hugo Vanderstichele, PhD, Malgorzata Knapik-Czajka, PhD*, Christopher M. Clark, MD*, Paul S. Aisen, MD, Ronald C. Petersen, MD, Kaj Blennow, MD, PhD, Holly Soares, PhD, Adam Simon, PhD, Piotr Lewczuk, MD, PhD, Robert Dean, MD, Eric Siemers, MD, William Potter, MD, Virginia M.‐Y. Lee, PhD*, John Q. Trojanowski, MD, PhD*, and the Alzheimer’s Disease Neuroimaging Initiative

*Names in bold font indicate people who were at the University of Pennsylvania when this article was published.

Fig 2. Plot of cerebrospinal fluid (CSF) tau concentration versus CSF amyloid-β 1 to 42 peptide (Aβ 1–42) concentration for the autopsy-confirmed Alzheimer’s disease (AD) cases (solid circles) and elderly cognitively normal (NC) subjects (open circles).
### Problem

About 3 percent of men and women ages 65 to 74 who have no symptoms of dementia have Alzheimer’s Disease.

1. What is the probability that a 70-year-old woman who has no symptoms of dementia has Alzheimer’s Disease if the test result for Aβ_{1-42} is positive?

2. What is the probability that such a person does not have Alzheimer’s Disease if the test result is negative?

### Five Ways to Revise the Probability of Disease Once the Test Result Is Known

1. Two-by-Two Table Method
   
   Use the standard 2×2 table.
   
   Step 1: Assume that there is some proportion of people who have the disease of interest. Pick a total number, and insert the other column totals.
   
   Step 2: Use the known sensitivity and specificity of the test to calculate the number of true positives and true negatives.
   
   True positives = sensitivity × prevalence
   
   True negatives = specificity × (1 − prevalence)
   
   Step 3: Subtract the true positives and true negatives from the column totals to give the number of false negatives (FN) and the number of false positives (FP).
   
   Step 4: Calculate the total number of positive test results and the total number of negative test results (row totals).
   
   Step 5: Calculate PPV and NPV
Step 1: Assume that there are 1000 people and the prevalence of disease is 3%. Insert the appropriate column totals.

<table>
<thead>
<tr>
<th></th>
<th>Disease Present</th>
<th>Disease Absent</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test Result</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Positive</td>
<td></td>
<td></td>
<td>30</td>
</tr>
<tr>
<td>Negative</td>
<td></td>
<td></td>
<td>970</td>
</tr>
<tr>
<td>Total</td>
<td>30</td>
<td>970</td>
<td>1000</td>
</tr>
</tbody>
</table>

Step 2: Use the known sensitivity (0.964) and specificity (0.788) of the test to calculate the number of true positives and true negatives.

<table>
<thead>
<tr>
<th></th>
<th>Disease Present</th>
<th>Disease Absent</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test Result</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Positive</td>
<td>29</td>
<td></td>
<td>30</td>
</tr>
<tr>
<td>Negative</td>
<td>764</td>
<td></td>
<td>970</td>
</tr>
<tr>
<td>Total</td>
<td>30</td>
<td>970</td>
<td>1000</td>
</tr>
</tbody>
</table>

Step 3: Subtract the true positives and true negatives from the column totals to give the number of false negatives (FN) and the number of false positives (FP).

<table>
<thead>
<tr>
<th></th>
<th>Disease Present</th>
<th>Disease Absent</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test Result</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Positive</td>
<td>29</td>
<td>206</td>
<td>30</td>
</tr>
<tr>
<td>Negative</td>
<td>1</td>
<td>764</td>
<td>764</td>
</tr>
<tr>
<td>Total</td>
<td>30</td>
<td>970</td>
<td>1000</td>
</tr>
</tbody>
</table>
Step 4: Calculate the total number of positive test results and the total number of negative test results.

<table>
<thead>
<tr>
<th>Disease</th>
<th>Disease Present</th>
<th>Disease Absent</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test Result Positive</td>
<td>29</td>
<td>206</td>
<td>235</td>
</tr>
<tr>
<td>Test Result Negative</td>
<td>1</td>
<td>764</td>
<td>765</td>
</tr>
<tr>
<td>Total</td>
<td>30</td>
<td>970</td>
<td>1000</td>
</tr>
</tbody>
</table>

Step 5: Calculate PPV and NPV

<table>
<thead>
<tr>
<th>Disease</th>
<th>Disease Present</th>
<th>Disease Absent</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test Result Positive</td>
<td>29</td>
<td>206</td>
<td>235</td>
</tr>
<tr>
<td>Test Result Negative</td>
<td>1</td>
<td>764</td>
<td>765</td>
</tr>
<tr>
<td>Total</td>
<td>30</td>
<td>970</td>
<td>1000</td>
</tr>
</tbody>
</table>

PPV = 29/235 = .123
NPV = 764/765 = .999

Five Ways to Revise the Probability of Disease Once the Test Result Is Known

2. Bayes Theorem Method

Where:
- $p$ = the prior probability of disease
- $sens$ = the sensitivity of the test
- $spec$ = the specificity of the test
- $PPV$ = positive predictive value
- $NPV$ = negative predictive value
\[
\text{PPV} = \frac{(p)(sens)}{[(p)(sens)] + [(1-p)(1-spec)]} \\
0.03 \times 0.964 \\
\text{PPV} = \frac{0.03 \times 0.964}{0.03 \times 0.964 + (0.97 \times 0.212)} \\
0.123
\]

\[
\text{NPV} = \frac{(1-p)(\text{spec})}{[(1-p)(\text{spec})] + [(p)(1-sens)]} \\
0.97 \times 0.788 \\
\text{NPV} = \frac{0.97 \times 0.788}{0.97 \times 0.788 + (0.03 \times 0.036)} \\
0.999
\]

<table>
<thead>
<tr>
<th>Disease Present</th>
<th>Disease Absent</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test Result Positive</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(p)(sens)</td>
<td>(1-p)(1-\text{spec}) or (1-p)(1-\text{spec})</td>
<td></td>
</tr>
<tr>
<td>Test Result Negative</td>
<td></td>
<td></td>
</tr>
<tr>
<td>p(x(1-sens)) or p(1-sens)</td>
<td>(1-p)(\text{spec})</td>
<td></td>
</tr>
<tr>
<td>Total p 1-p 1</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
\[
\text{PPV} = \frac{(p)(\text{sens})}{[(p)(\text{sens})] + [(1-p)(1-\text{spec})]}
\]

\( (p)(\text{sens}) = \) number of true-positive results
\( (1-p)(1-\text{spec}) = \) number of false-positive results
\( \text{PPV} = \) number of true positives / number of all positives

\[
\text{NPV} = \frac{(1-p)(\text{spec})}{[(1-p)(\text{spec})] + [(p)(1-\text{sens})]}
\]

\( (1-p)(\text{spec}) = \) number of true-negative results
\( (p)(1-\text{sens}) = \) number of false-negative results
\( \text{NPV} = \) number of true negatives / number of all negatives

**Likelihood Ratios**

- Likelihood ratios report the number of times those with disease have the test result for every 1 time those without disease have the test result
- If the LR is 5 (or 5 to 1), then the test result occurs 5 times among diseased individuals for every 1 time it occurs among nondiseased individuals (e.g., if it is positive 50% of the time among diseased individuals, it is positive 10% of the time among nondiseased individuals).
- If the LR is 0.2 (or 0.2 to 1), then the test result occurs 0.2 times among diseased individuals for every 1 time it occurs among nondiseased individuals (e.g., if it is negative 2% of the time among diseased individuals, it is negative 10% of the time among nondiseased individuals).
Calculating the Likelihood Ratio

Probability of positive test in patients with disease

\[ LR^+ = \frac{\text{Sensitivity}}{\text{1 - Specificity}} \]

Probability of positive test in patients without disease

\[ LR^+ = \frac{\text{Sensitivity}}{\text{1 - Specificity}} \]

Probability of negative test in patients with disease

\[ LR^- = \frac{\text{1 - Sensitivity}}{\text{Specificity}} \]

Probability of negative test in patients without disease

\[ LR^- = \frac{\text{1 - Sensitivity}}{\text{Specificity}} \]

<table>
<thead>
<tr>
<th></th>
<th>Disease Present</th>
<th>Disease Absent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test Result</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Positive</td>
<td>54</td>
<td>11</td>
</tr>
<tr>
<td>Negative</td>
<td>2</td>
<td>41</td>
</tr>
<tr>
<td>Total</td>
<td>56</td>
<td>52</td>
</tr>
</tbody>
</table>

Sensitivity = 54/56 = 0.964
Specificity = 41/52 = 0.788

\[ LR^+ = \frac{0.964}{0.212} = 4.547 \]

\[ LR^- = \frac{0.036}{0.788} = 0.046 \]
Interpreting Odds in Horse Racing

1. If your horse wins, you collect the amount of money you bet plus the amount of money you bet times the odds.

   Chances of losing

2. Odds = ------------------

   Chances of winning

Odds are NOT probabilities

   Odds = ------------------

   Chances of losing
   Chances of winning

   Probability = ------------------

   Chances of losing
   Chances of winning plus chances of winning
# Moving from probabilities to odds

odds = probability/(1 – probability)

<table>
<thead>
<tr>
<th>Probability</th>
<th>Prob/(1-Prob)</th>
<th>Odds</th>
</tr>
</thead>
<tbody>
<tr>
<td>60%</td>
<td>60%/40%</td>
<td>1.5</td>
</tr>
<tr>
<td>75%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>½</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.25</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

# Moving from odds to probabilities

probability = odds/(1 + odds)

<table>
<thead>
<tr>
<th>Probability</th>
<th>Odds/(1+Odds)</th>
<th>Odds</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.2</td>
<td>(1/4)/(5/4)</td>
<td>1/4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1/3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4/1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.5</td>
</tr>
</tbody>
</table>

---

### Five Ways to Revise the Probability of Disease Once the Test Result Is Known

3. Revising the Probability of Disease with the LR, Method A

Step 1: Change the prior probability of disease into the prior odds of disease.

Step 2: Calculate the posterior odds of disease by multiplying the likelihood ratio (either positive or negative) times the prior odds.

Step 3: Change the posterior odds of disease into the posterior probability of disease.
**Our Example**

Probability = 0.03, LR+ = 4.547, LR- = 0.046

Step 1. Change the prior probability of disease into the prior odds of disease

Odds = .03 / .97 = .031

Step 2. To calculate the posterior odds of disease, multiply the likelihood ratio (positive or negative) times the prior odds

Posterior odds of disease = 

(LR+ * .031) = (4.547*.031) = .141

(LR- * .031) = (.046*.031) = .001

---

**Our Example**

Step 3. Change the posterior odds of disease into the posterior probability of disease

Posterior probability of disease = .141/1.141 = .124

Posterior probability of disease = .001/1.001 = .001

The second result (for LR-) is the probability of disease in a patient with a negative test result. One minus this number, or 0.999, is the probability of no disease in a person with a negative test result, which is the NPV.

---

**Five Ways to Revise the Probability of Disease**  
**Once the Test Result Is Known**

4. Revising the Probability of Disease with the LR, Method B

Henry derived a new equation by replacing the numbers in the steps for the traditional method with algebraic expressions, as follows. Note that LR indicates either LR+ or LR-.

- Change the prior probability into the prior odds of disease
  
  Prior odds = (Prior probability) / (1 - Prior probability)

- Calculate the posterior odds by multiplying the prior odds times the likelihood ratio.
  
  Post. odds = (Prior odds) / (1 - Prior probability) = LR

- Change the posterior odds into the posterior probability by dividing the posterior odds by:

  1 + (Prior probability) / (1 - Prior probability) = LR

  1 + (Prior probability) / (1 - Prior probability) = LR

  1 + (Prior probability) / (1 - Prior probability) = LR
4. Revising the Probability of Disease with the LR, Method B, continued

- Multiply numerator and denominator times \((1 - \text{Prior probability})\), which results in:

\[
\text{Posterior} \times \text{Prior Probability} \times \text{LR} \quad = \quad \text{Probability of Disease} \quad = \quad \frac{\text{Posterior} \times \text{Prior Probability} \times \text{LR}}{1 - \text{Prior probability} + \text{Prior probability} \times \text{LR}}
\]

- Rearrange the terms in the denominator:

\[
\text{Posterior} \times \text{Prior Probability} \times \text{LR} \quad = \quad \text{Probability of Disease} \quad = \quad \frac{\text{Posterior} \times \text{Prior Probability} \times \text{LR}}{1 - \text{Prior probability} + \text{Prior probability} \times \text{LR}}
\]

Our Example

\[
\text{Probability} = .03, \text{LR+} = 4.547, \text{LR-} = .046
\]

\[
\begin{align*}
\text{Posterior} \times \text{Prior Probability} \times \text{LR} \quad & = \quad \text{Probability of Disease} \quad = \quad \frac{\text{Posterior} \times \text{Prior Probability} \times \text{LR}}{1 - \text{Prior probability} + \text{Prior probability} \times \text{LR}} \\
0.03 \times 4.547 \quad & = \quad \frac{0.03 \times 4.547 \times (1 - 0.03)}{0.03 \times 4.547 + (1 - 0.03)} \\
0.03 \times 0.046 \quad & = \quad \frac{0.03 \times 0.046 + (1 - 0.03)}{0.03 \times 4.547 + (1 - 0.03)} \\
\end{align*}
\]

The second result (using LR-) is the probability of disease in a patient with a negative test result. One minus this number, or 0.999, is the probability of no disease in a person with a negative test result, which is the NPV.
Five Ways to Revise the Probability of Disease Once the Test Result Is Known

5. Revising the Probability of Disease with the LR, Method C

- Locate the prior probability of disease on the right vertical axis of the nomogram P(D)
- Locate the LR on the middle vertical axis of the nomogram
- Draw a straight line between these 2 points, and extend it until it intersects the left vertical axis of the nomogram P(D|T)
- If the test result is positive, read the posterior probability of disease from the left vertical axis
- If the test result is negative, the posterior probability of no disease (NPV) is 1 minus the value on the left vertical axis of the nomogram

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Five Ways to Revise the Probability of Disease (Calculate the Predictive Value of the Test Result) Once the Test Result Is Known

1. Two-by-Two Table Method
2. Bayes Theorem Method
3. LR, Method A, Traditional Method
4. LR, Method B, Henry’s Equation
5. LR, Method C, Nomogram