## Basic Definitions and Concepts

<table>
<thead>
<tr>
<th></th>
<th>Present</th>
<th>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>A</td>
<td>B</td>
<td>N₁ = A+B</td>
</tr>
<tr>
<td>Negative</td>
<td>C</td>
<td>D</td>
<td>N₂ = C+D</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>M₁ = A+C</td>
<td>M₂ = B+D</td>
<td>N₁+N₂ = M₁+M₂</td>
</tr>
</tbody>
</table>

Prevalence \( = \frac{M₁}{M₁ + M₂} = \frac{A + C}{A + B + C + D} \)

Sensitivity \( = \frac{A}{M₁} = \frac{A}{A + C} \)

Specificity \( = \frac{D}{M₂} = \frac{D}{B + D} \)

\( PV^+ = \frac{A}{N₁} = \frac{A}{A + B} \)

\( PV^- = \frac{D}{N₂} = \frac{D}{C + D} \)

Pre-test Odds \( = \frac{Pre-test\ Probability}{1 - Pre-test\ Probability} \)

\( LR^+ = \frac{Sensitivity}{1 - Specificity} \)

\( LR^- = \frac{1 - Sensitivity}{Specificity} \)

Post-test Odds given Positive Test Result \( = Pre-test\ Odds \times LR^+ \)

Post-test Odds given Negative Test Result \( = Pre-test\ Odds \times LR^- \)

Post-test Probability of Disease Given Positive Test \( = \frac{Post-test\ Odds\ given\ Positive\ Test}{1 + Post-test\ Odds\ given\ Positive\ Test} \)

Post-test Probability of Disease Given Negative Test \( = \frac{Post-test\ Odds\ given\ Negative\ Test}{1 + Post-test\ Odds\ given\ Negative\ Test} \)
Examples

The following example was extracted verbatim from "Medical Epidemiology by Greenberg RS, Daniels SR, Flanders WD, Eley JW, and Boring JR III. McGraw-Hill Companies, New York, 2001."

Introduction

A 54-year-old high school teacher visited her family practitioner for an annual checkup. She reported no illness during the preceding year, felt well, and had no complaints. The hot flashes she had experienced a year ago had resolved without treatment. The physician performed a physical examination, comprising breast, pelvic (including a Papanicolaou smear), and rectal examinations; all were unremarkable. The physician recommended that the patient have a mammogram, which was scheduled for I week later.

The results of the mammogram were not normal, and the radiologist suggested that a breast biopsy be performed. The family practitioner notified the patient of the abnormal mammogram and referred her to a surgeon, who concurred that physical examination of the breast was normal. Based on the mammographic abnormality, however, the surgeon and the radiologist agreed that fine needle aspiration (FNA) of the abnormal breast under radiologic guidance was indicated. Evaluation of the FNA specimen by a pathologist revealed cancer cells, and the patient was scheduled for further surgery by the following week. (Greenberg RS, et. Medical Epidemiology).

Bibbo, et al (1988) compared FNA results with the gold standard, surgical excisional biopsy (removal and histopathologic examination of tissue) in 114 consecutive women with normal physical examination and abnormal mammograms. The results of the study are summarized in the following table:

<table>
<thead>
<tr>
<th>Surgical Biopsy</th>
<th>Cancer</th>
<th>No cancer</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>FNA Result</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Positive</td>
<td>14</td>
<td>8</td>
<td>22</td>
</tr>
<tr>
<td>Negative</td>
<td>1</td>
<td>91</td>
<td>92</td>
</tr>
<tr>
<td>Total</td>
<td>15</td>
<td>99</td>
<td>114</td>
</tr>
</tbody>
</table>


1. What is the prevalence (%) of breast cancer among women without palpable breast masses?
   \[ P = \text{Prevalence} = \frac{15}{114} \times 100 = 13.2\% \]

2. What is the sensitivity (in %) of the test described?
   \[ \text{SNout} = \frac{14}{15} \times 100 = 93.3\% \]
3. What is the specificity (in %) of the test described?

\[ SPin = \frac{91}{99} \times 100 = 91.9\% \]

4. What is the positive predictive value (in %) of the test?

\[ PV+ = \frac{14}{99} \times 100 = 63.6\% \]

5. What is the negative predictive value (in %) of the test?

\[ PV- = \frac{91}{92} \times 100 = 98.9\% \]

6. What is the likelihood ratio for a positive finding of the test?

\[ LR+ = \frac{SNout}{1 - SPin} = \frac{0.933}{1 - 0.919} = 11.55 \]

7. What is the likelihood ratio for a negative finding of the test?

\[ LR- = \frac{1 - SNout}{SPin} = \frac{1 - 0.933}{0.919} = 0.0725 \]

8. If the test is applied to a patient with a pretest probability of cancer of 13%, what are the pretest odds of breast cancer?

\[ \text{Pre-test odds} = \frac{0.13}{1 - 0.13} = \frac{0.13}{0.87} = 0.149 \]

9. For the patient described in question 8, what are the posttest odds of breast cancer following a positive screening test?

\[ \text{Post-test odds} = \text{Pre-test odds} \times LR+ = 0.149 \times 11.55 = 1.726 \]

10. What is the posttest probability of breast cancer following a positive test?

\[ \text{Post-test Probability} = \frac{\text{Post Test Odds}}{1 + \text{Post test Odds}} \times 100 = \frac{1.726}{2.726} = 63\% \]
Smith C et al (Surgery 1988;103:178) carried out a similar experiment among women with palpable masses. Their findings are summarized in the following table.

<table>
<thead>
<tr>
<th>FNA Result</th>
<th>Cancer</th>
<th>No cancer</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Positive</td>
<td>113</td>
<td>15</td>
<td>128</td>
</tr>
<tr>
<td>Negative</td>
<td>8</td>
<td>181</td>
<td>189</td>
</tr>
<tr>
<td>Total</td>
<td>121</td>
<td>196</td>
<td>317</td>
</tr>
</tbody>
</table>

Comparison of FNA test results with findings from surgical excisional biopsies in women with palpable breast masses (Smith C, et al. Surgery 1988;103:178)

1. What is the prevalence (%) of breast cancer among women with palpable breast masses?

\[ P = \text{Prevalence} = \frac{121}{317} \times 100 = 38.2\% \]

2. What is the sensitivity (in %) of the test described?

\[ SN_{out} = \frac{113}{121} \times 100 = 93.4\% \]

3. What is the specificity (in %) of the test described?

\[ SP_{in} = \frac{181}{196} \times 100 = 92.3\% \]

4. What is the positive predictive value (in %) of the test?

\[ PV_{+} = \frac{113}{128} \times 100 = 88.3\% \]

5. What is the negative predictive value (in %) of the test?

\[ PV_{-} = \frac{181}{189} \times 100 = 95.8\% \]

6. What is the likelihood ratio for a positive finding of the test?

\[ LR_{+} = \frac{SN_{out}}{1 - SP_{in}} = \frac{0.934}{1 - 0.923} = 12.2 \]

7. What is the likelihood ratio for a negative finding of the test?

\[ LR_{-} = \frac{1 - SN_{out}}{SP_{in}} = \frac{1 - 0.934}{0.923} = 0.0716 \]

8. If the test is applied to a patient with a pretest probability of cancer of 38%, what are the pretest odds of breast cancer?
9. For the patient described in question 8, what are the posttest odds of breast cancer following a positive screening test?

\[
\text{Post-test odds} = \text{Pre-test odds} \times LR^+ = 0.613 \times 12.2 = 7.48
\]

10. What is the posttest probability of breast cancer following a positive test?

\[
\text{Post-test Probability} = \frac{\text{Post Test Odds}}{1 + \text{Post test Odds}} \times 100 = \frac{7.48}{8.48} = 88\%
\]

11. What is the posttest probability of breast cancer following a negative test?

\[
\text{Post-test odds} = \text{Pre-test odds} \times LR^- = 0.613 \times 0.716 = 0.439
\]

\[
\text{Post-test Probability} = \frac{\text{Post Test Odds}}{1 + \text{Post test Odds}} \times 100 = \frac{0.439}{1.439} = 31\%
\]