ROC (Receiver Operating Characteristic) Curve Analysis

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Agenda

➢ Introduction
➢ Definition
➢ Accuracy
➢ Application
➢ Conclusion
➢ Reference
Introduction

➢ ROC (Receiver Operating Characteristic) curve is a fundamental tool for diagnostic test evaluation. It is increasingly used in many fields, such as data mining, financial credit scoring, weather forecasting etc.

➢ ROC curve plots the true positive rate (sensitivity) of a test versus its false positive rate (1-specificity) for different cut-off points of a parameter

➢ ROC curve is graphically to display the trade-off relationship between sensitivity and specificity for all possible thresholds

➢ SAS/STAT Procedures: FREQ, LOGISTIC, MIXED and NLMIXED can be used to perform ROC curve analysis
ROC (Receiver Operating Characteristic) Curve\(^1\)
**Definition**

- Sensitivity is the probability of a test will be positive given a patient with the disease.
- Specificity is the probability of a test will be negative given a patient without the disease.

### Table

<table>
<thead>
<tr>
<th>Test</th>
<th>Disease</th>
<th>Present</th>
<th>Absent</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Positive</td>
<td>True Positive (TP)</td>
<td>$a$</td>
<td>$c$</td>
<td>$a+c$</td>
</tr>
<tr>
<td>Negative</td>
<td>False Negative (FN)</td>
<td>$b$</td>
<td>$d$</td>
<td>$b+d$</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>$a+b$</td>
<td>$c+d$</td>
<td></td>
</tr>
</tbody>
</table>

Sensitivity = $\frac{TP}{(TP+FN)} = \frac{a}{a+b}$

Specificity = $\frac{TN}{(TN+FP)} = \frac{d}{c+d}$

Positive predictive value (PPV) = $\frac{TP}{(TP+FP)} = \frac{a}{a+c}$

Negative predictive value (NPV) = $\frac{TN}{(TN+FN)} = \frac{d}{b+d}$
Accuracy

➢ The accuracy of a test is measured by the area under the ROC curve (AUC).

➢ AUC is the area between the curve and the x axis.

➢ An area of 1 represents a perfect test, while an area of .5 represents a worthless test.

➢ The closer the curve follows the left-upper corner of the plot, the more accurate the test.
PROC FREQ: 2×2 contingency table in PET (Positron Emission Tomography) scan for detecting cancer

**data cancer;**
input Diagnosed $ Observed $ patients;
datalines;
  Cancer Cancer 25
  Cancer No_Cancer 3
  No_Cancer Cancer 42
  No_Cancer No_Cancer 111
;
run;

Proc freq data=cancer;
table diagnosis*observed;
weight patients;
run;

Diagnosed cancer if SUV (Standardized Uptake Value) > 7;
Observed cancer determined by gold standard

Sensitivity = 37.31%
Specificity = 97.37%
PPV = 89.29%
NPV = 72.55%
Application in SAS

- Developing new biomarkers (BM) that are more specific in detecting drug induced liver injury (DILI) than the commonly used test [elevated alanine transaminase (ALT)]

```sas
ods graphics on;
proc logistic data = biom plots = roc;
model status (event='1') = alt bm1 bm2;
  roc “BM1’ bm1;
  roc “BM2” bm2;
  roc “ALT” alt;
  roccontrast reference(‘ALT’)/estimate e;
run;
ods graphics off;
```

AUC equals to C-statistics
Conclusion

➢ Threshold Selection
  - To choose the most appropriate cut-off for a test. The best cut-off has the highest true positive rate together with the lowest false positive rate

➢ Assessment of Diagnostic Accuracy
  - To evaluate the accuracy of a diagnostic test using AUC value to discriminate the diseased cases from normal cases

➢ Multiple Tests Comparison
  - To compare the performance of two or more tests via a visual method
Reference


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