

# Diagnostic test

1

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2026/4/28

# 內容大綱

- Hosmer and Lemeshow test (goodness of fit)
- Bland–Altman plot
- Receiver Operating Characteristic (ROC) Curve Analysis

# Hosmer and Lemeshow test

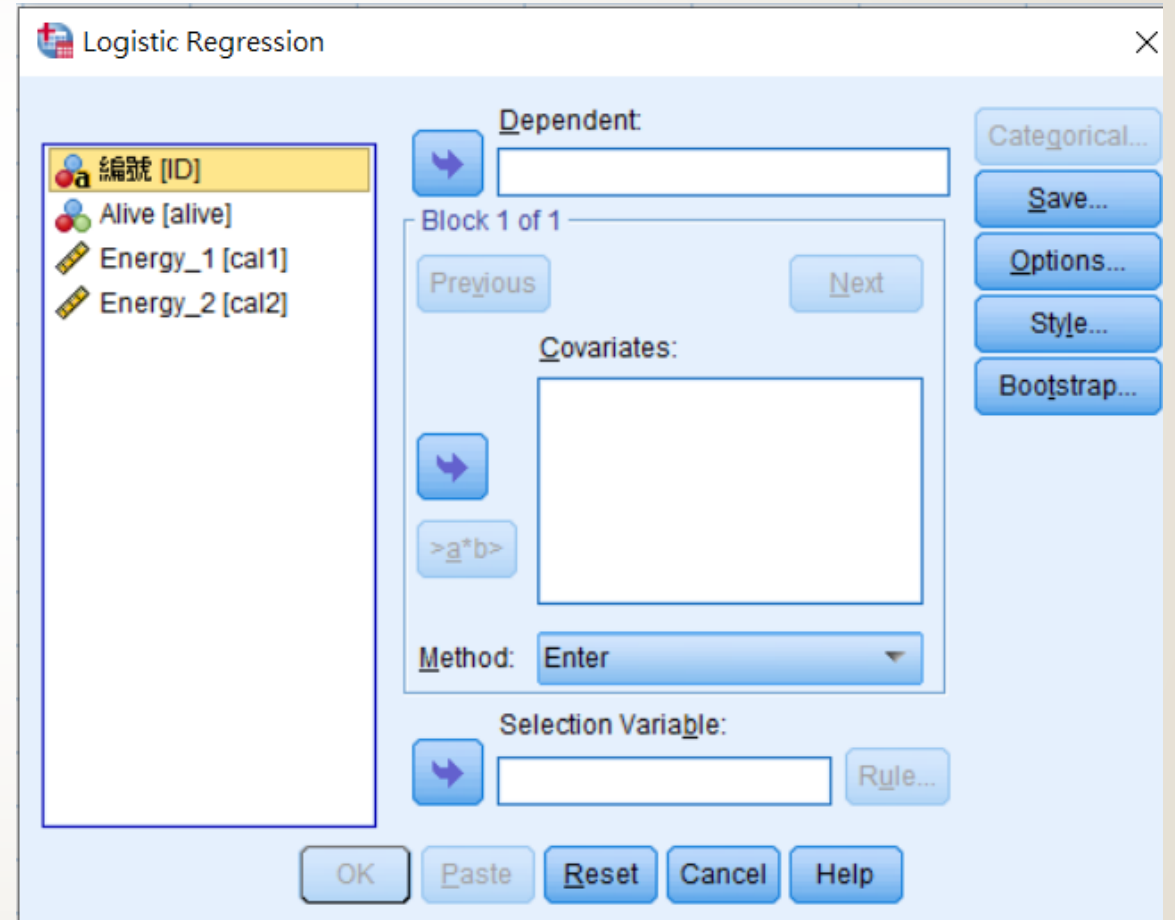
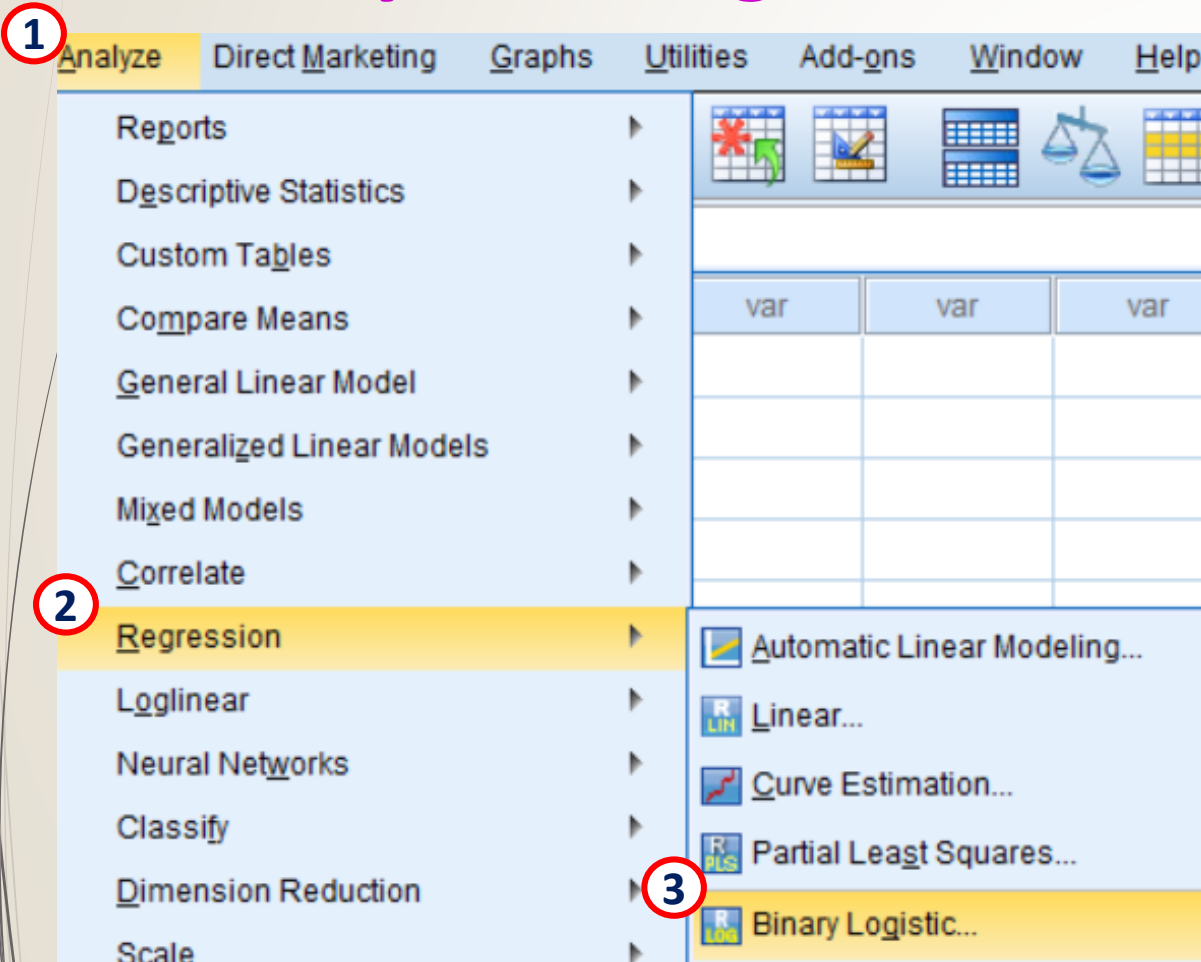
- ▶ 對logistic迴歸模型擬合優度的檢定方法
  - ▶ 根據預測機率值將資料分成大致相同規模的10個組
  - ▶ 將觀測資料按其預測機率做升序排列
    - ▶ 第一組機率最小
    - ▶ 最後一組估計機率最大

# Hosmer and Lemeshow test

- ▶ 類似於Pearson Chi-Square統計量的指標
  - ▶ 可從觀察值和預測值構成的2\*G交互表中求得
  - ▶ HL指標與Chi-Square分佈相比較
    - ▶  $p > 0.05$  (Acceptable Calibration)

# Hosmer and Lemeshow test (SPSS)

► Analyze → Regression → Binary Logistic



# Hosmer and Lemeshow test (SPSS)

► Analyze → Regression → Binary Logistic

The image shows two overlapping dialog boxes from SPSS. The background window is the "Logistic Regression" dialog, and the foreground window is the "Logistic Regression: Options" dialog.

**Logistic Regression Dialog (Background):**

- Dependent:** Alive [alive]
- Covariates:** cal1
- Method:** Enter
- Buttons:** Previous, Next, Categorical..., Save..., Options... (circled with a red box and the number 4)

**Logistic Regression: Options Dialog (Foreground):**

- Statistics and Plots:**
  - Classification plots
  - Hosmer-Lemeshow goodness-of-fit (circled with a red box and the number 5)
  - Casewise listing of residuals
  - Outliers outside 2 std. dev.
  - All cases
  - Display: At each step (selected), At last step
- Probability for Stepwise:** Entry: 0.05, Removal: 0.10
- Classification cutoff:** 0.5
- Maximum Iterations:** 20
- Conserve memory for complex analyses or large datasets
- Include constant in model
- Buttons:** Continue, Cancel, Help

# Hosmer and Lemeshow test (SPSS)

► Analyze → Regression → Binary Logistic

Hosmer and Lemeshow Test

Step	Chi-square	df	Sig.
1	7.332	7	.395

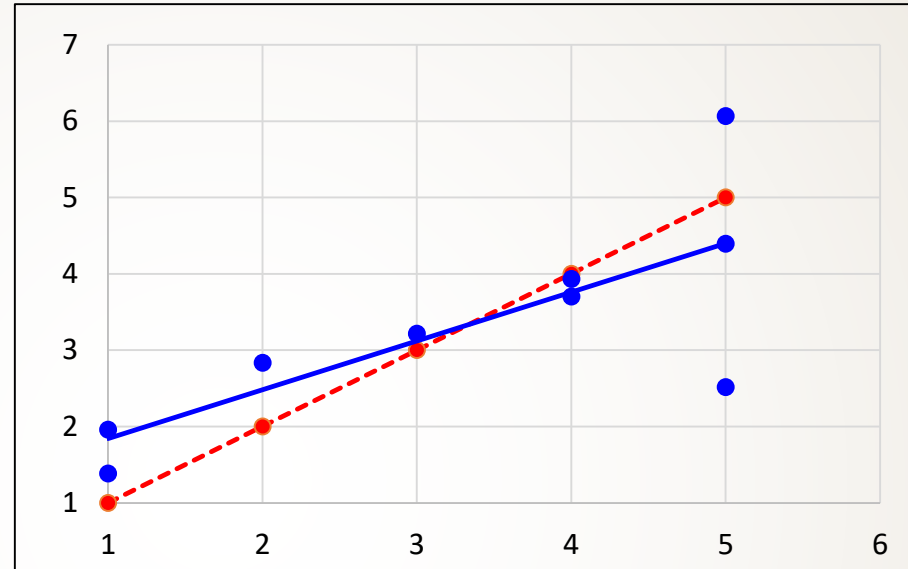
$p > 0.05$   
Acceptable  
calibration

Contingency Table for Hosmer and Lemeshow Test

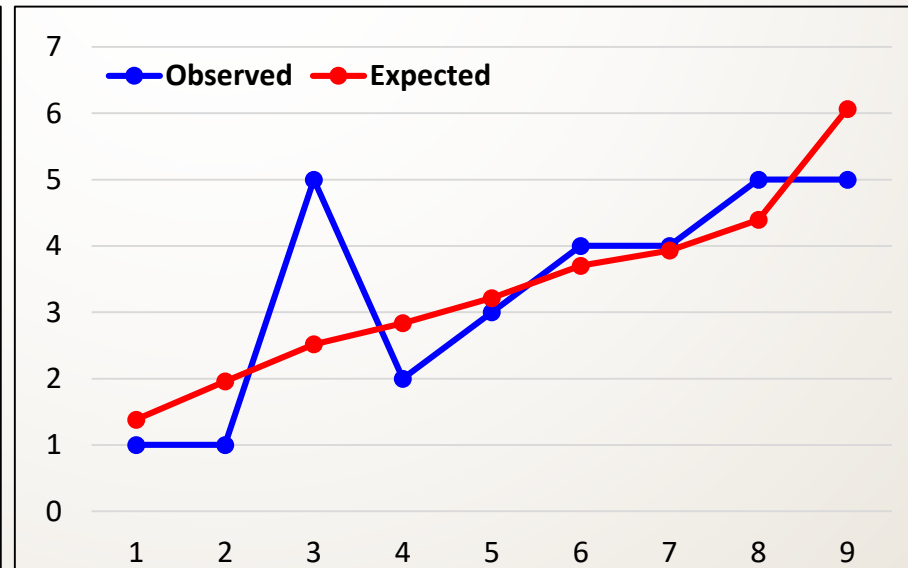
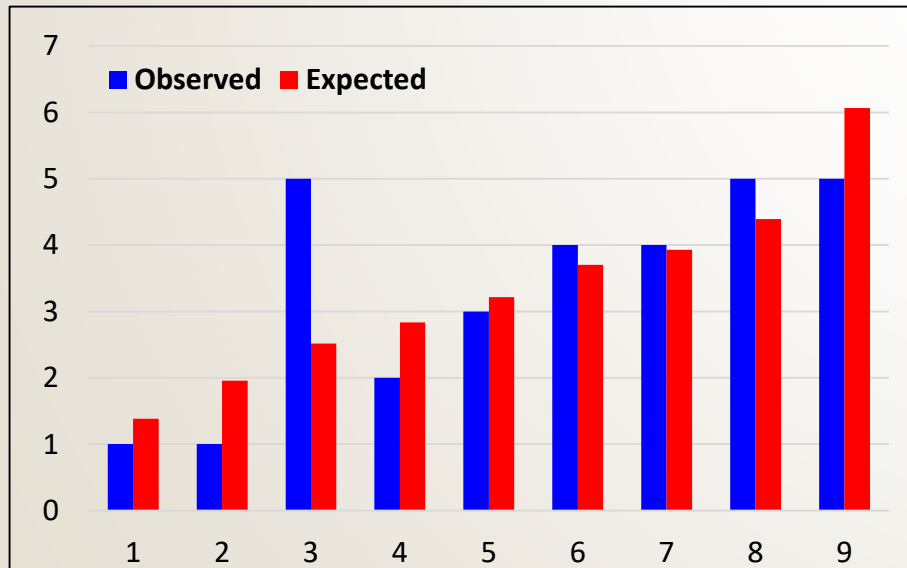
		Alive = Death		Alive = Alive		Total
		Observed	Expected	Observed	Expected	
Step 1	1	5	4.618	1	1.382	6
	2	5	4.041	1	1.959	6
	3	1	3.483	5	2.517	6
	4	4	3.165	2	2.835	6
	5	3	2.785	3	3.215	6
	6	2	2.298	4	3.702	6
	7	2	2.070	4	3.930	6
	8	1	1.606	5	4.394	6
	9	2	.935	5	6.065	7

# Hosmer and Lemeshow test (SPSS & Excel)

- Scatter plot
- Bar chart
- Line chart

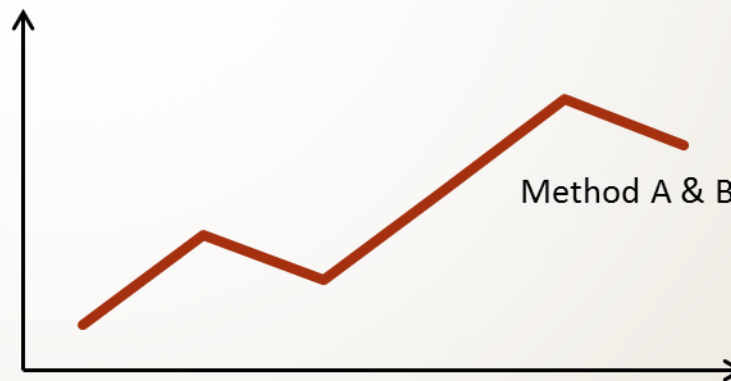
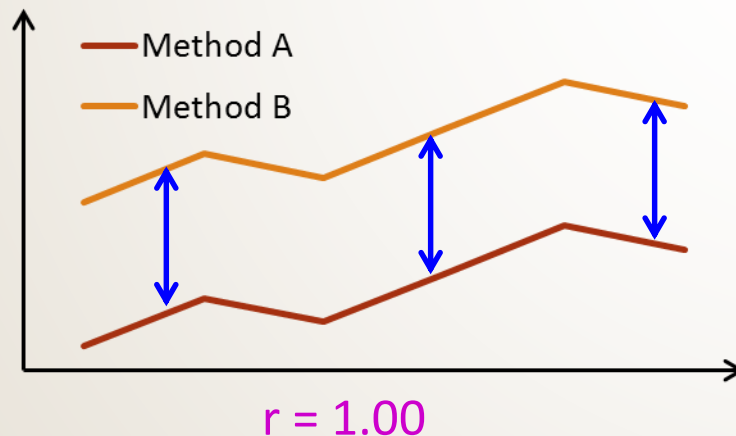


Alive = Alive	
Observed	Expected
1	1.382
1	1.959
5	2.517
2	2.835
3	3.215
4	3.702
4	3.930
5	4.394
5	6.065



# Bland–Altman plot

- The agreement between two quantitative methods of measurement
  - correlation coefficient ( $r$ )
    - the relationship between one variable and another
    - not the differences (not recommended)



# Bland–Altman plot

- The agreement between two quantitative methods of measurement
  - Bland–Altman plot
    - In 1983 Altman and Bland (B&A) proposed
    - Mean difference and constructing limits of agreement

# Bland–Altman plot

## ► Scatter plot

### ► Y axis

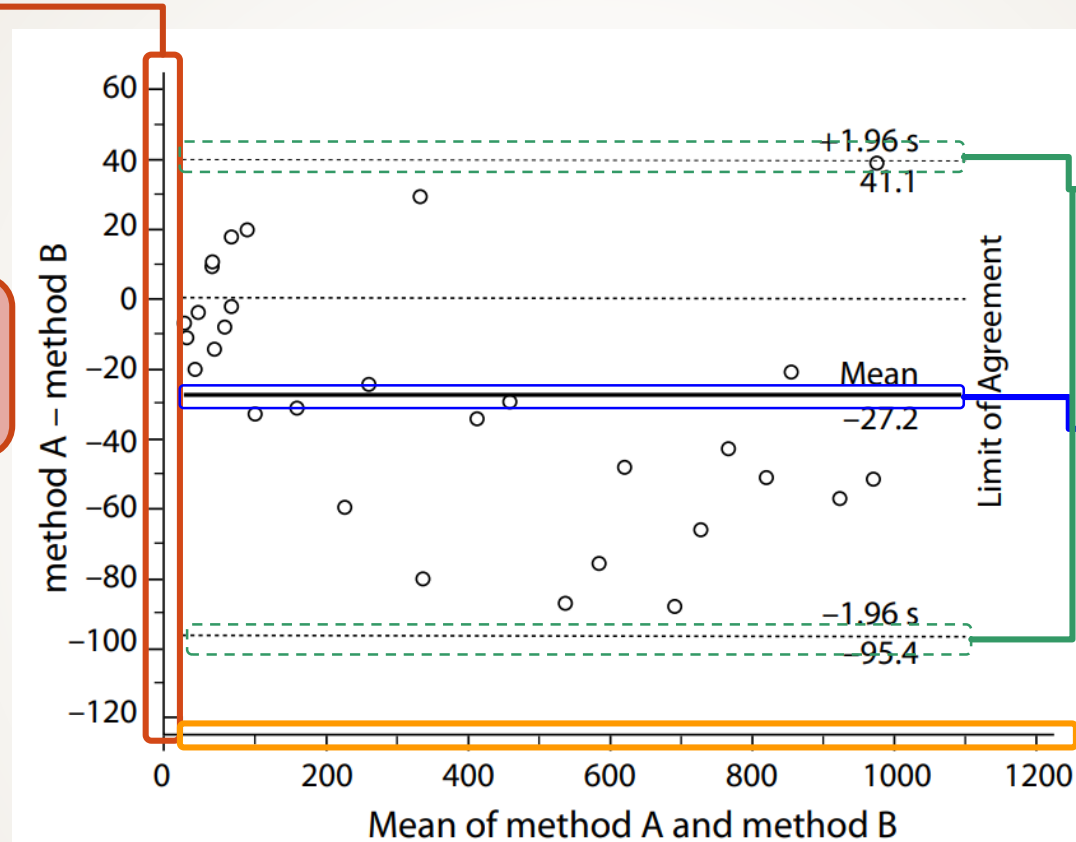
- The difference between the two paired measurements (A-B)
- Normally distributed (Gaussian) - 95% of differences  $d \pm 1.96s$ 
  - not normally distributed - logarithmic transformation

### ► X axis

- The average of these measures  $((A+B)/2)$

# Bland-Altman plot

Y軸：兩種測量的差異(A-B)  
顯示兩者之間的誤差大小



上下虛線：一致性界線  
標記95%誤差分佈的範圍

中間實線：平均差值  
兩種工具間的系統性偏差

X軸：兩種方法的平均值  
作為真實數值的最佳估計

**FIGURE 5.** Bland and Altman plot for data from the table 1, with the representation of the limits of agreement (dotted line), from  $-1.96s$  to  $+1.96s$ .

# Bland–Altman plot (SPSS)

➔ **Graphs → Legacy Dialogs → Scatter/Dot**

TABLE 1. Hypothetical data of an agreement between two methods (Method A and B).

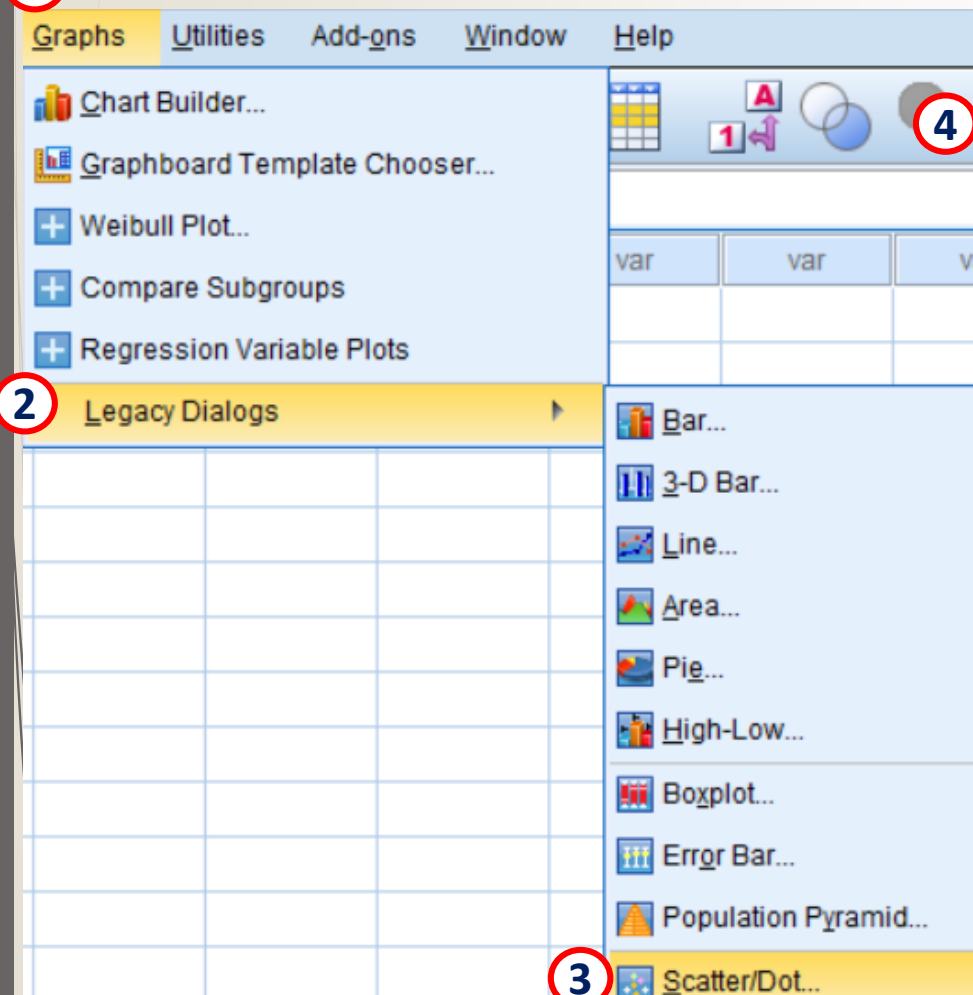
Method A (units)	Method B (units)	Mean (A+B)/2 (units)	(A - B) (units)	(A - B)/ Mean (%)
1.0	8.0	4.5	-7.0	-155.6%
5.0	16.0	10.5	-11.0	-104.8%
10.0	30.0	20.0	-20.0	-100.0%
20.0	24.0	22.0	-4.0	-18.2%
50.0	39.0	44.5	11.0	24.7%
40.0	54.0	47.0	-14.0	-29.8%
50.0	40.0	45.0	10.0	22.2%
60.0	68.0	64.0	-8.0	-12.5%
70.0	72.0	71.0	-2.0	-2.8%
80.0	62.0	71.0	18.0	25.4%
90.0	122.0	106.0	-32.0	-30.2%
100.0	80.0	90.0	20.0	22.2%
150.0	181.0	165.5	-31.0	-18.7%
200.0	259.0	229.5	-59.0	-25.7%
250.0	275.0	262.5	-25.0	-9.5%

1

2

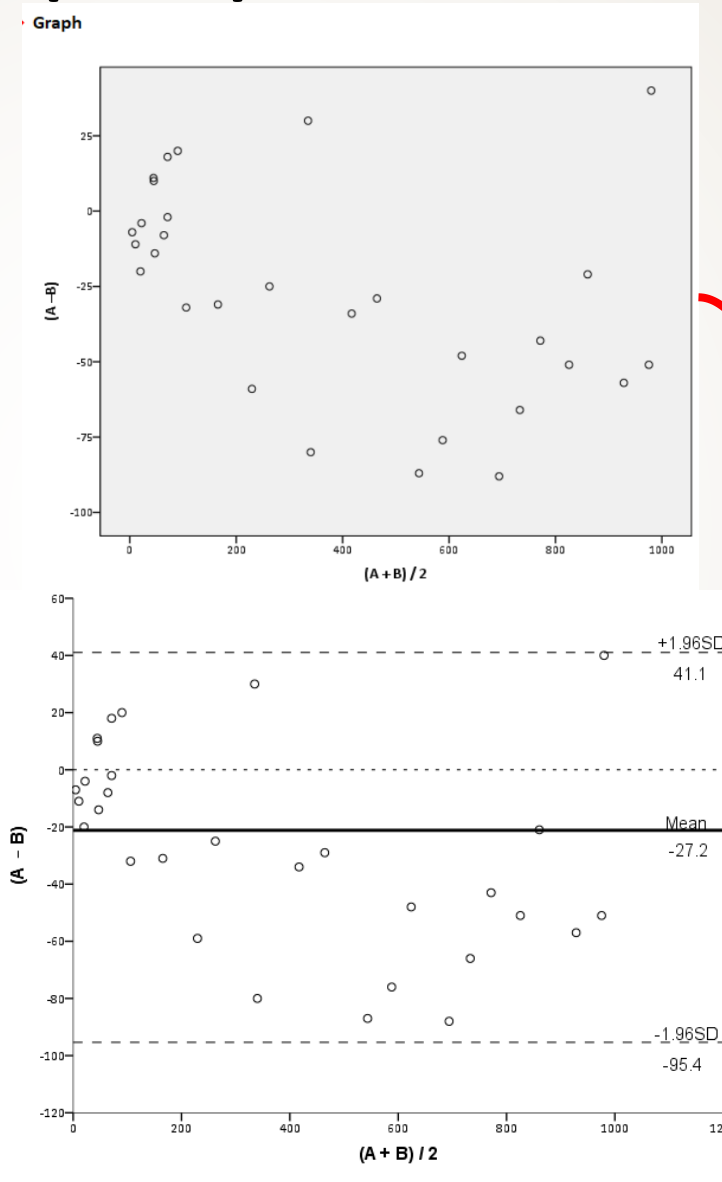
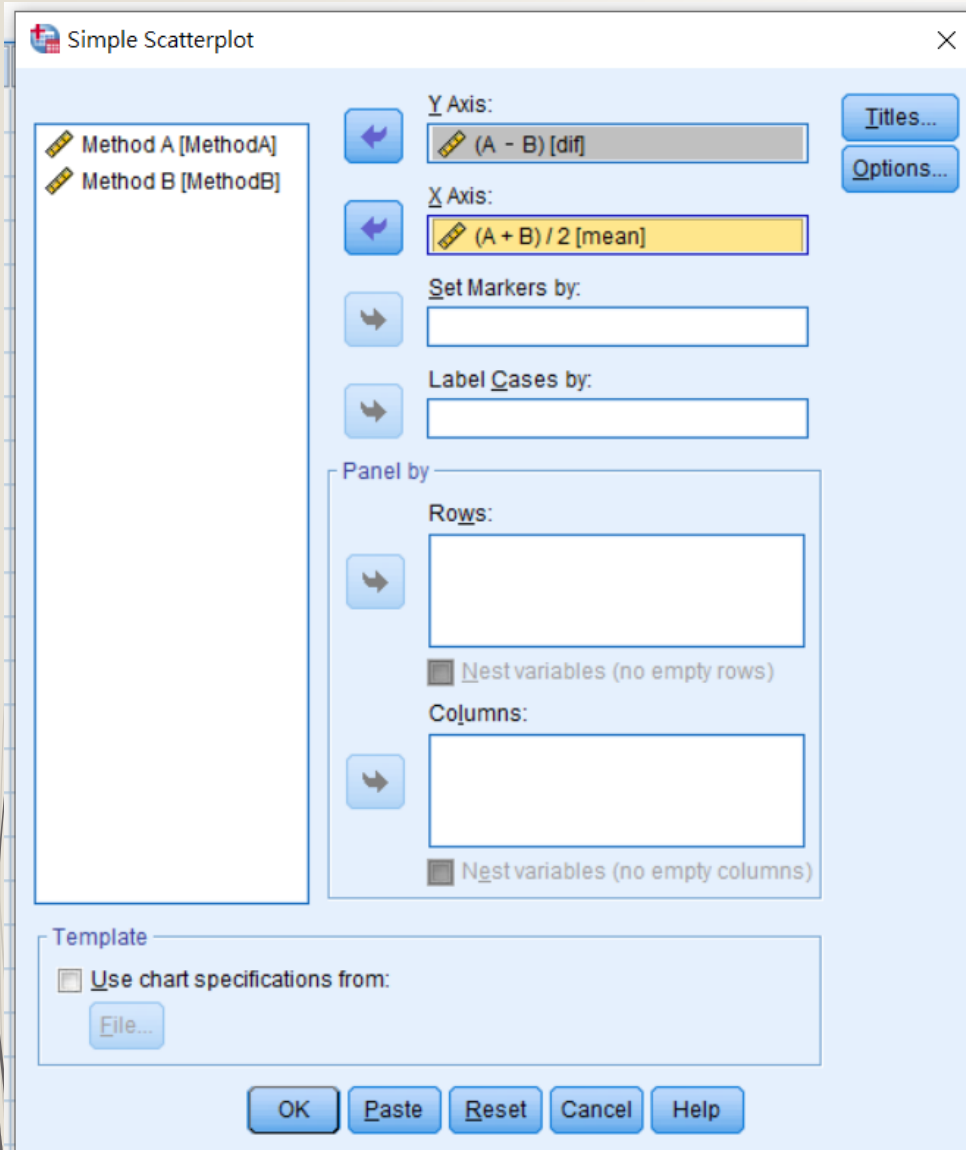
3

4



MethodA	MethodB	mean	dif	
1	8	5	-7	
5	16	11	-11	
10	30	20	-20	
20	24	22	-4	
5	50	39	45	11
6	40	54	47	-14
7	50	40	45	10
8	60	68	64	-8
9	70	72	71	-2
10	80	62	71	18

# Bland-Altman plot (SPSS)

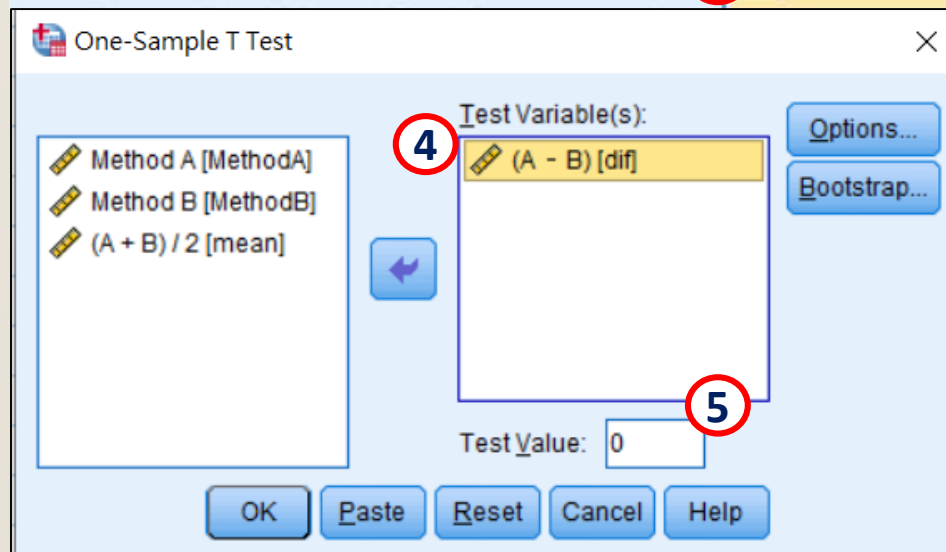
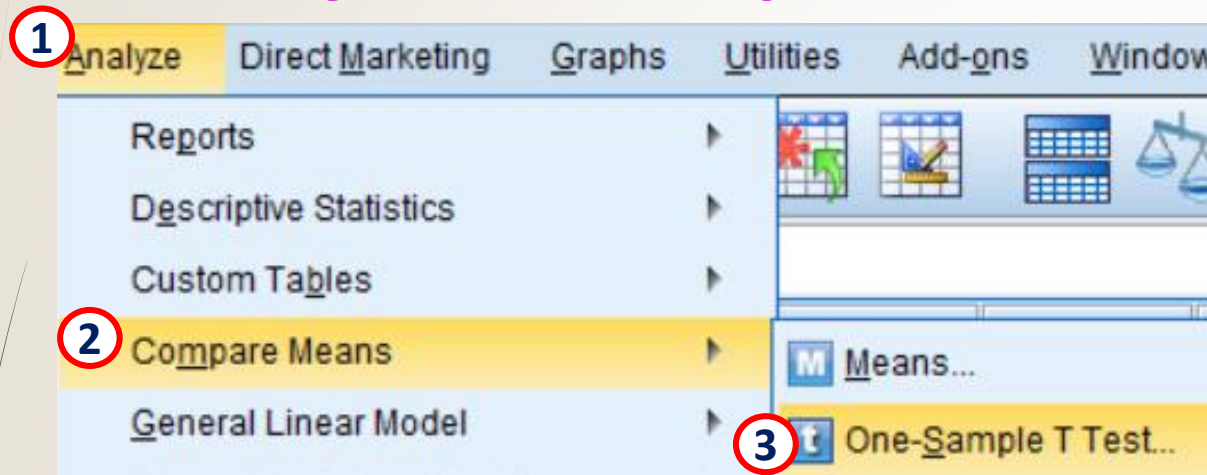


**TABLE 1.** Hypothetical data of an agreement between two methods (Method A and B).

Method A (units)	Method B (units)	Mean (A+B)/2 (units)	(A - B) (units)	(A - B)/ Mean (%)
1.0	8.0	4.5	-7.0	-155.6%
5.0	16.0	10.5	-11.0	-104.8%
10.0	30.0	20.0	-20.0	-100.0%
20.0	24.0	22.0	-4.0	-18.2%
50.0	39.0	44.5	11.0	24.7%
40.0	54.0	47.0	-14.0	-29.8%
50.0	40.0	45.0	10.0	22.2%
60.0	68.0	64.0	-8.0	-12.5%
70.0	72.0	71.0	-2.0	-2.8%
80.0	62.0	71.0	18.0	25.4%
90.0	122.0	106.0	-32.0	-30.2%
100.0	80.0	90.0	20.0	22.2%
150.0	181.0	165.5	-31.0	-18.7%
200.0	259.0	229.5	-59.0	-25.7%
250.0	275.0	262.5	-25.0	-9.5%
300.0	380.0	340.0	-80.0	-23.5%
350.0	320.0	335.0	30.0	9.0%
400.0	434.0	417.0	-34.0	-8.2%
450.0	479.0	464.5	-29.0	-6.2%
500.0	587.0	543.5	-87.0	-16.0%
550.0	626.0	588.0	-76.0	-12.9%
600.0	648.0	624.0	-48.0	-7.7%
650.0	738.0	694.0	-88.0	-12.7%
700.0	766.0	733.0	-66.0	-9.0%
750.0	793.0	771.5	-43.0	-5.6%
800.0	851.0	825.5	-51.0	-6.2%
850.0	871.0	860.5	-21.0	-2.4%
900.0	957.0	928.5	-57.0	-6.1%
950.0	1001.0	975.5	-51.0	-5.2%
1000.0	960.0	980.0	40.0	4.1%

# Bland–Altman plot (SPSS)

➔ Analyze → Compare Means → One-Sample T test



➔ T-Test

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
(A - B)	30	-27.17	34.806	6.355

One-Sample Test

	Test Value = 0					
	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
(A - B)	-4.275	29	.000	-27.167	-40.16	-14.17

# Bland–Altman plot (MedCalc)

➔ **Statistics** → **Method comparison & evaluation** → **Bland–Altman plot**

1

2

3

	A	B
	Method_A	Method_B
1	1	8
2	5	16
3	10	30
4	20	24
5	50	39
6	40	54
7	50	40
8	60	68
9	70	72

Bland-Altman plot

First method:

Method\_A  
Method\_B

Options

Plot against (X-axis): Mean of both methods

Plot differences  
 Plot differences as %  
 Plot ratios

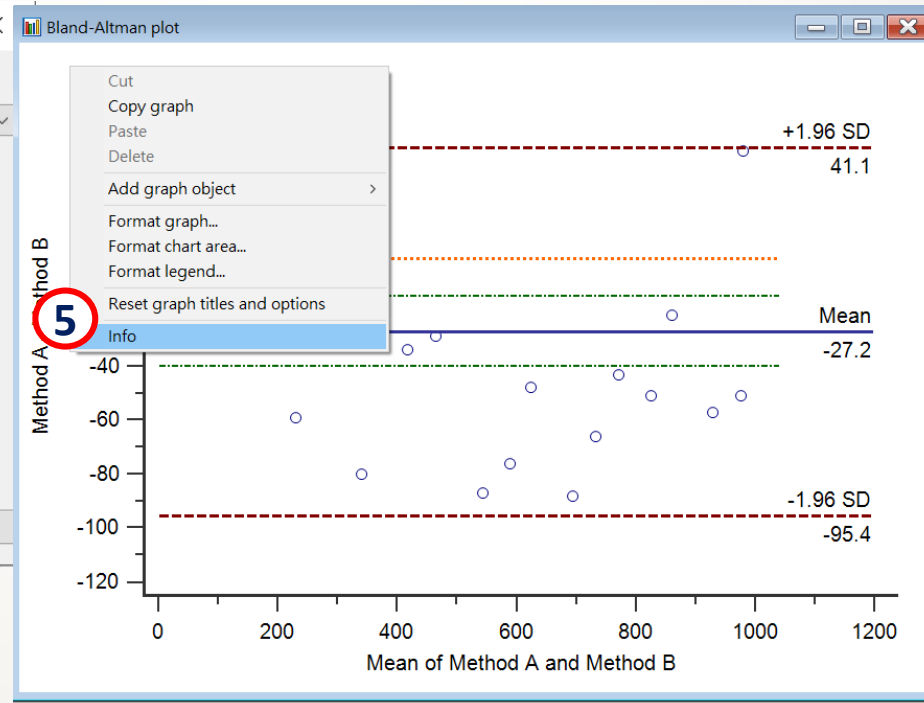
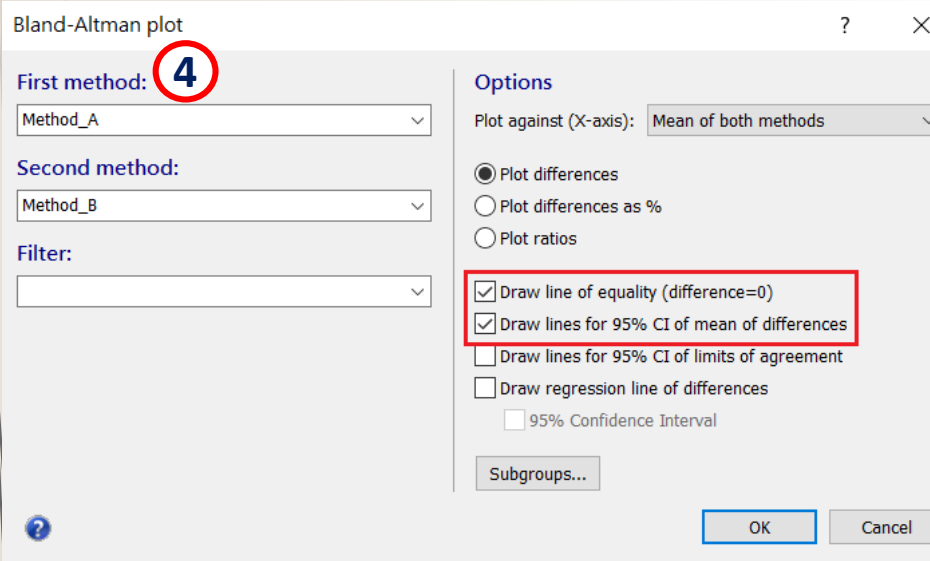
Draw line of equality (difference=0)  
 Draw lines for 95% CI of mean of differences  
 Draw lines for 95% CI of limits of agreement  
 Draw regression line of differences  
 95% Confidence Interval

Subgroups...

OK Cancel

# Bland-Altman plot (MedCalc)

➔ Statistics → Method comparison & evaluation → Bland-Altman plot



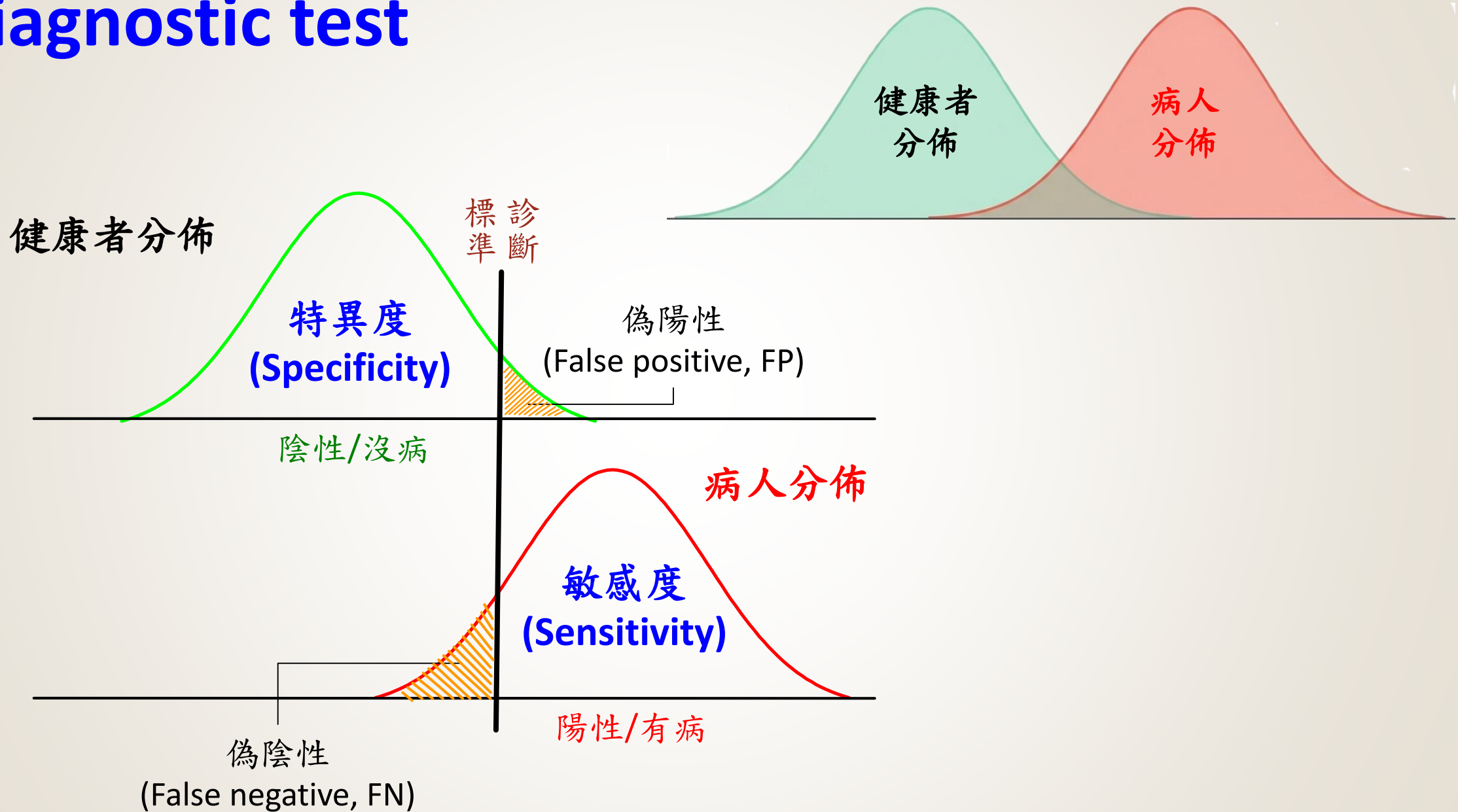
Bland-Altman plot

Method A Method\_A  
Method A  
Method B Method\_B  
Method B

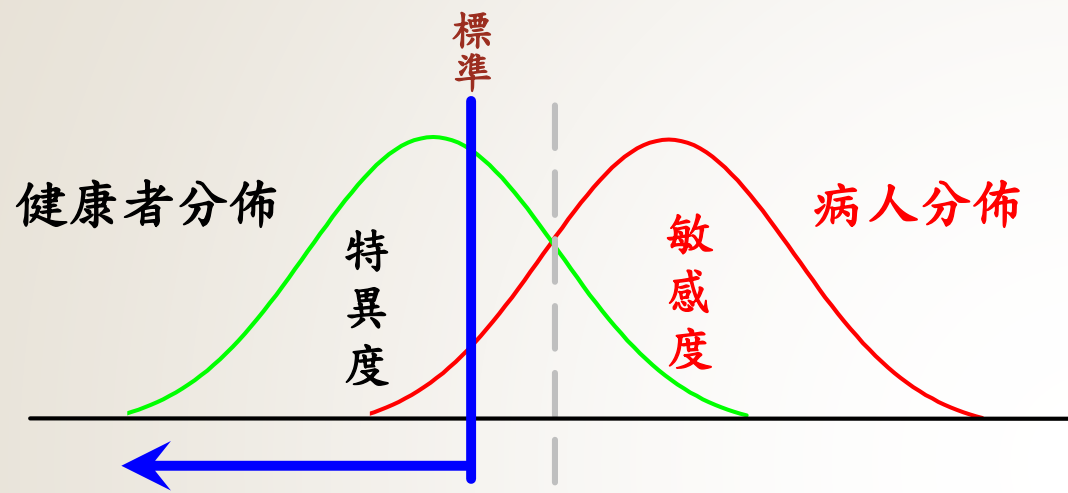
## Differences

Sample size	30
Arithmetic mean	-27.1667
95% CI	-40.1634 to -14.1699
<b>P (H<sub>0</sub>: Mean=0)</b>	<b>0.0002</b>
Standard deviation	34.8059
Lower limit	-95.3863
95% CI	-117.8487 to -72.9240
Upper limit	41.0530
95% CI	18.5906 to 63.5153

# Diagnostic test



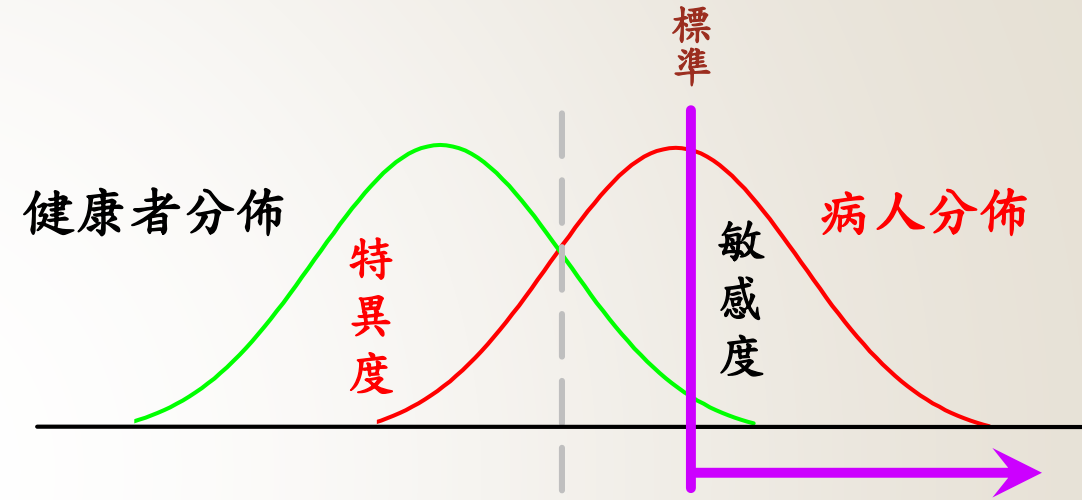
# Diagnostic test



寬鬆

敏感度 (Sensitivity) 上升

特異度 (Specificity) 下降



嚴格

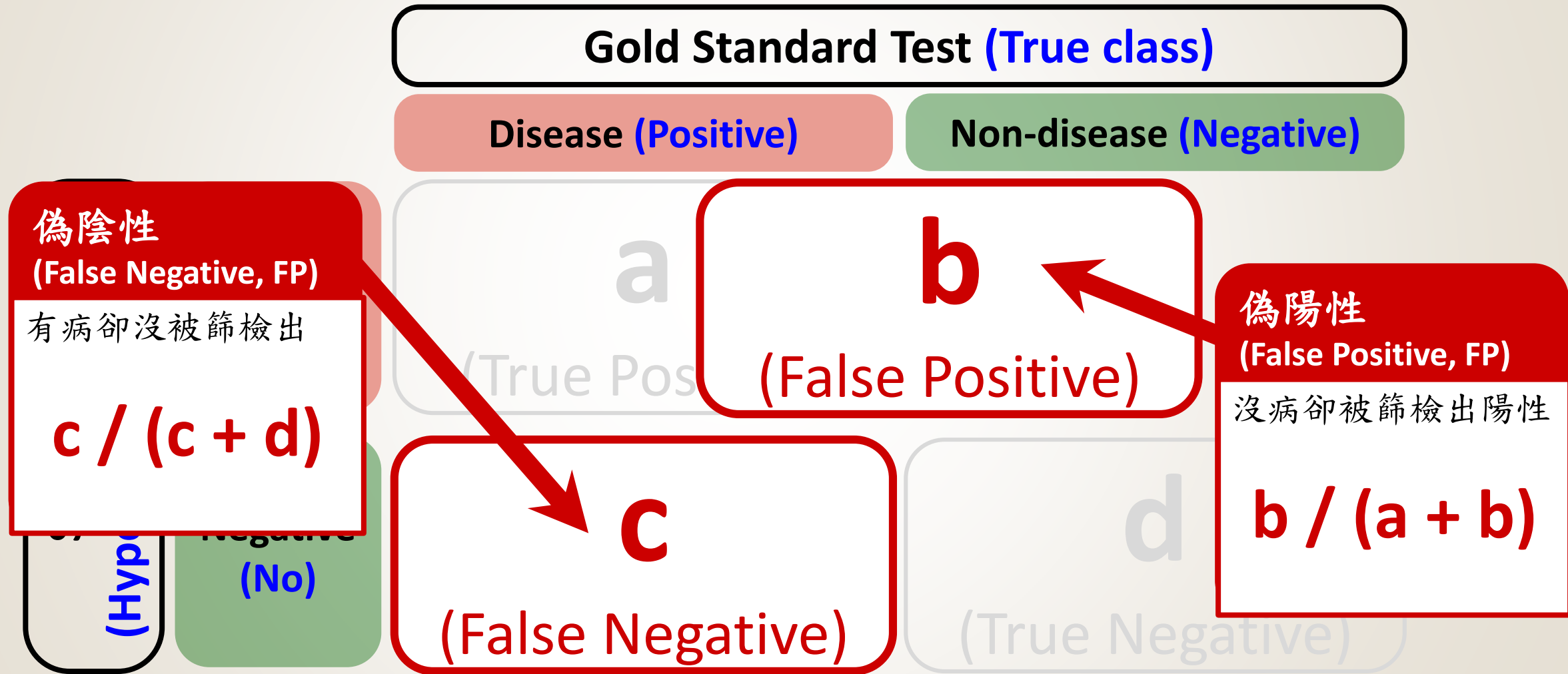
敏感度 (Sensitivity) 下降

特異度 (Specificity) 上升

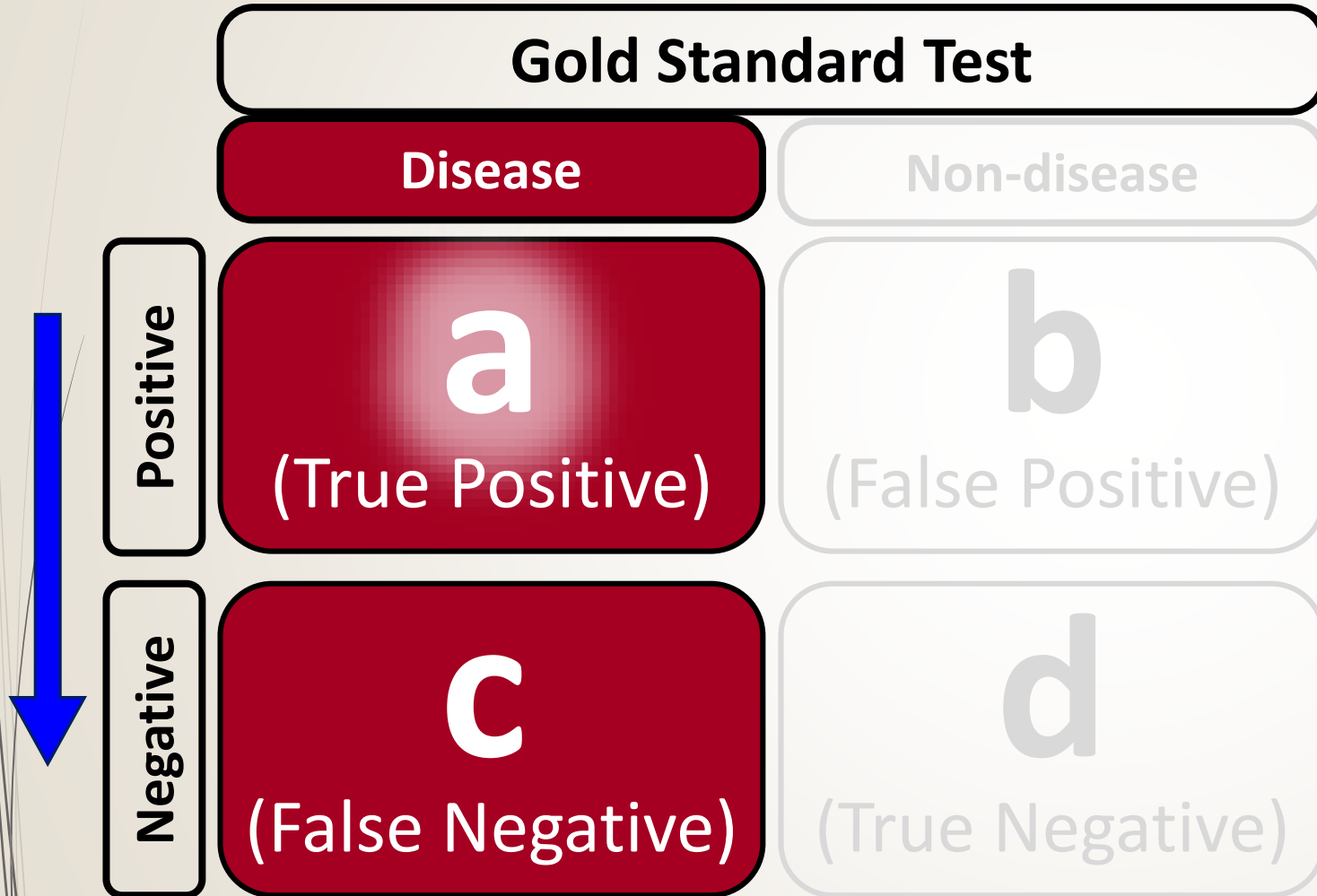
# Diagnostic test

		Gold Standard Test (True class)	
		Disease (Positive)	Non-disease (Negative)
Screen Test (Hypothesized Class)	Positive (Yes)	<b>a</b> (True Positive)	<b>b</b> (False Positive)
	Negative (No)	<b>c</b> (False Negative)	<b>d</b> (True Negative)

# Diagnostic test



# Diagnostic test



$$\text{Sensitivity (敏感度)} = \frac{a}{(a+c)}$$

# Diagnostic test

## Gold Standard Test

Disease

Non-disease

Positive

**a**

(True Positive)

**b**

(False Positive)

Negative

**c**

(False Negative)

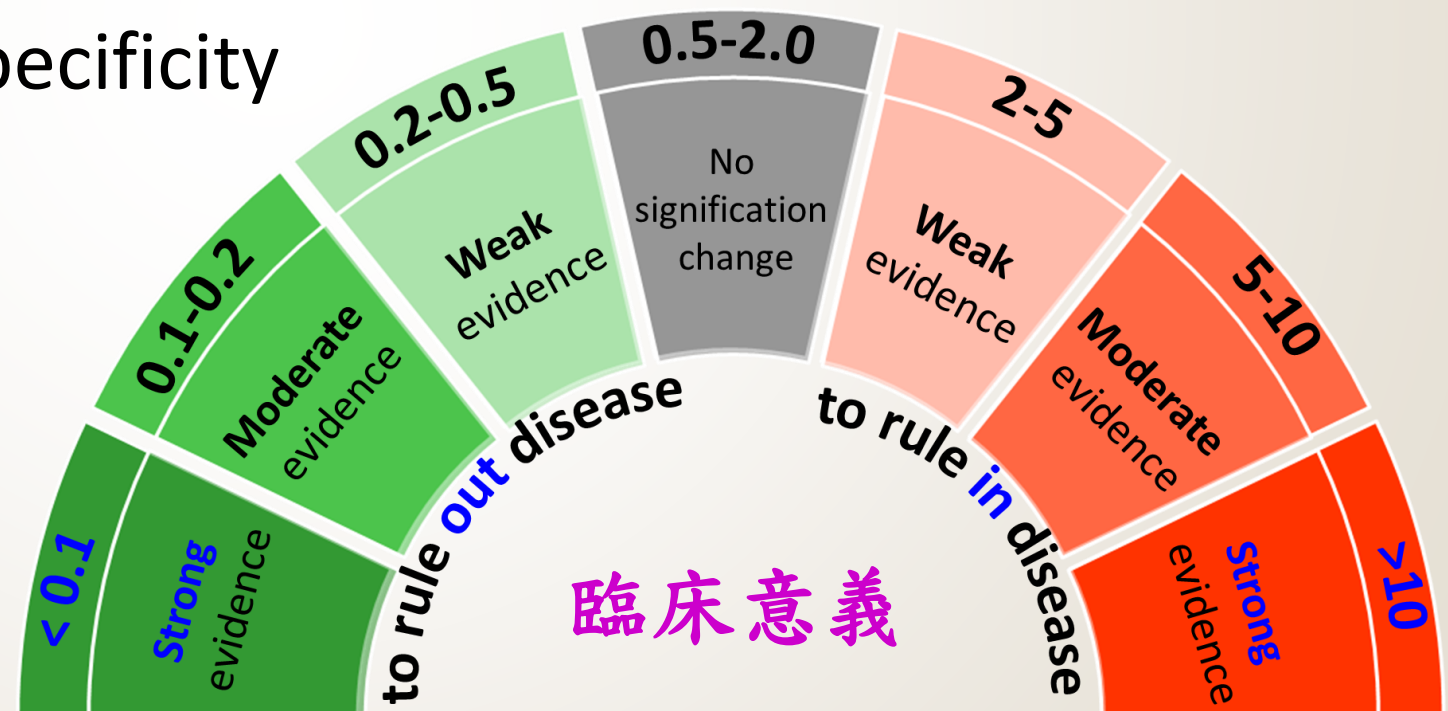
**d**

(True Negative)

$$\text{Specificity (特異度)} = \frac{d}{(b+d)}$$

# Diagnostic test

- ▶ Likelihood ratio positive (LR+)
  - ▶ Sensitivity / (1 – Specificity)
- ▶ Likelihood ratio negative (LR-)
  - ▶ (1 – Sensitivity) / Specificity



# Diagnostic test

**PPV**

Screen Test	Disease	Non-disease
Positive	<b>a</b>	<b>b</b>
Negative	<b>c</b>	<b>d</b>

$$\text{Positive predictive value (PPV)} = \frac{a}{(a+b)}$$

**NPV**

	Disease	Non-disease
Positive	<b>a</b>	<b>b</b>
Negative	<b>c</b>	<b>d</b>

$$\text{Negative predictive value (NPV)} = \frac{d}{(c+d)}$$

# Diagnostic test

	Disease	Health
Positive	<sup>sen</sup> true positive	false positive
Negative	false negative	<sup>spe</sup> true negative

$$PPV = \frac{\text{true positive}}{\text{all positive}} = \frac{\text{true positive}}{\text{true positive} + \text{false positive}}$$

**true positive**  
 = **all cases** \* sensitivity

$$NPV = \frac{\text{true negative}}{\text{all negative}} = \frac{\text{true negative}}{\text{true negative} + \text{false negative}}$$

**false positive**  
 = **all health** \* (1 - specificity)

**all cases** = total \* **prevalence**

**all health** = total \* (1 - **prevalence**)

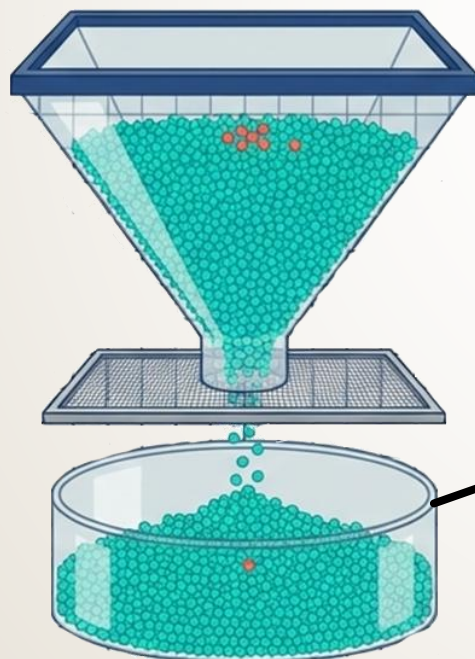
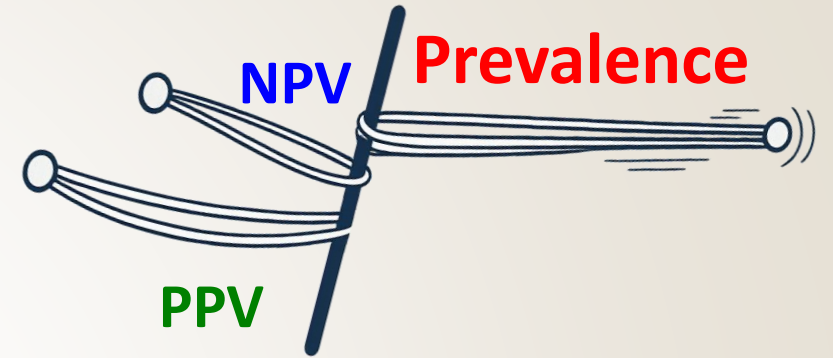
$$PPV = \frac{(\text{total} * \text{prevalence}) * \text{sensitivity}}{(\text{total} * \text{prevalence}) * \text{sensitivity} + (\text{total} * (1 - \text{prevalence}) * (1 - \text{specificity}))}$$

$$= \frac{\text{prevalence} * \text{sensitivity}}{(\text{prevalence} * \text{sensitivity}) + (1 - \text{prevalence}) * (1 - \text{specificity})}$$

$$NPV = \frac{(1 - \text{prevalence}) * \text{specificity}}{(1 - \text{prevalence}) * \text{specificity} + \text{prevalence} * (1 - \text{sensitivity})}$$

# Diagnostic test

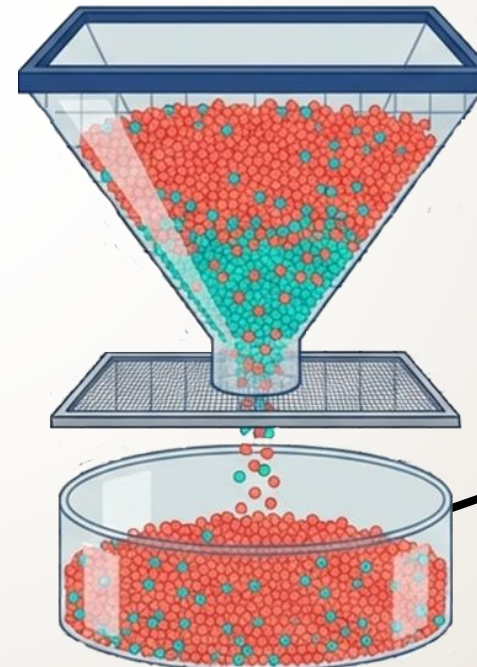
- Prevalence
  - PPV / NPV



Low  
Prevalence

PPV 低  
NPV 高

Positive results



High  
Prevalence

PPV 高  
NPV 低

Positive results

# Diagnostic test

評估患者風險 (PPV & NPV) → 受「盛行率」影響

（敏感度 & 特異度）  
評估篩檢工具

<b>真陽性 (True Positive)</b> 有病且篩檢陽性 $\text{Sensitivity} = \frac{\text{TP}}{(\text{TP} + \text{FN})}$	<b>偽陽性 (False Positive)</b> 沒病但篩檢陽性 $(1 - \text{Specificity}) = \frac{\text{FP}}{(\text{FP} + \text{TN})}$
<b>偽陰性 (False Negative)</b> 有病但篩檢陰性 $(1 - \text{Sensitivity}) = \frac{\text{FN}}{(\text{TP} + \text{FN})}$	<b>真陰性 (True Negative)</b> 沒病且篩檢陰性 $\text{Specificity} = \frac{\text{TN}}{(\text{FP} + \text{TN})}$

# ROC Curve Analysis

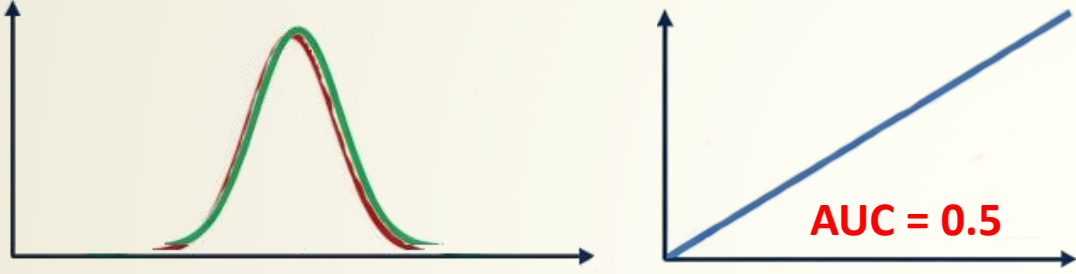
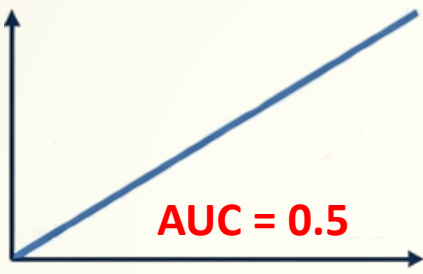
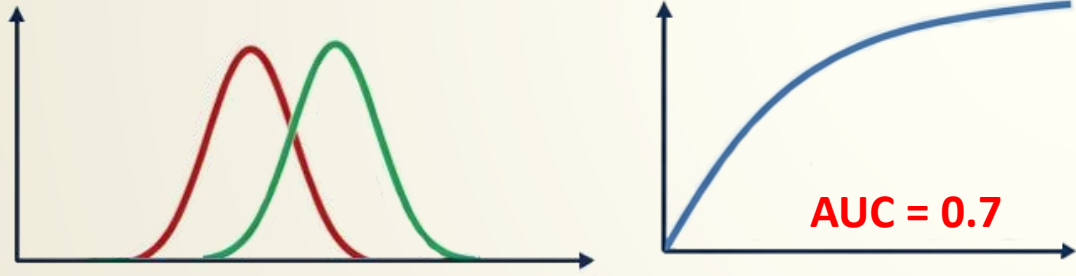
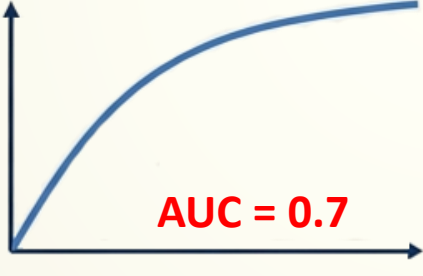
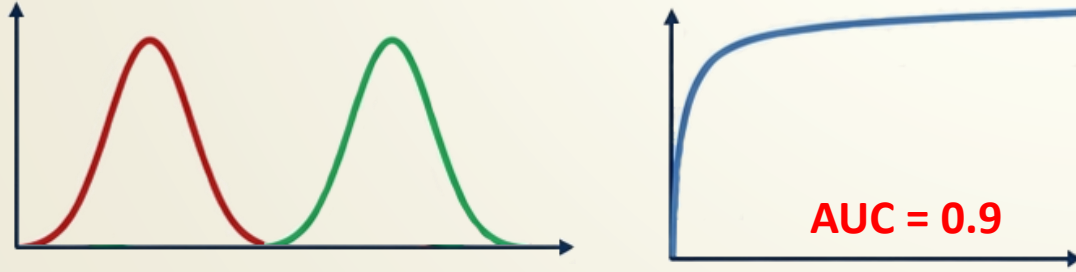
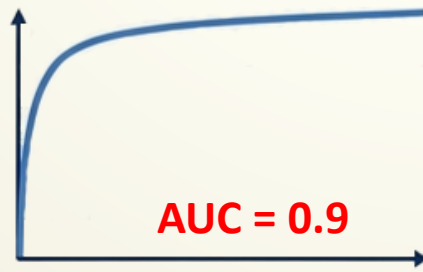
## ► 使用時機

- 當開發新的檢驗方法，無法決定臨界值 (Cut-off value)
- 利用連續數值預測結果 (二元分類)

## ► 目的

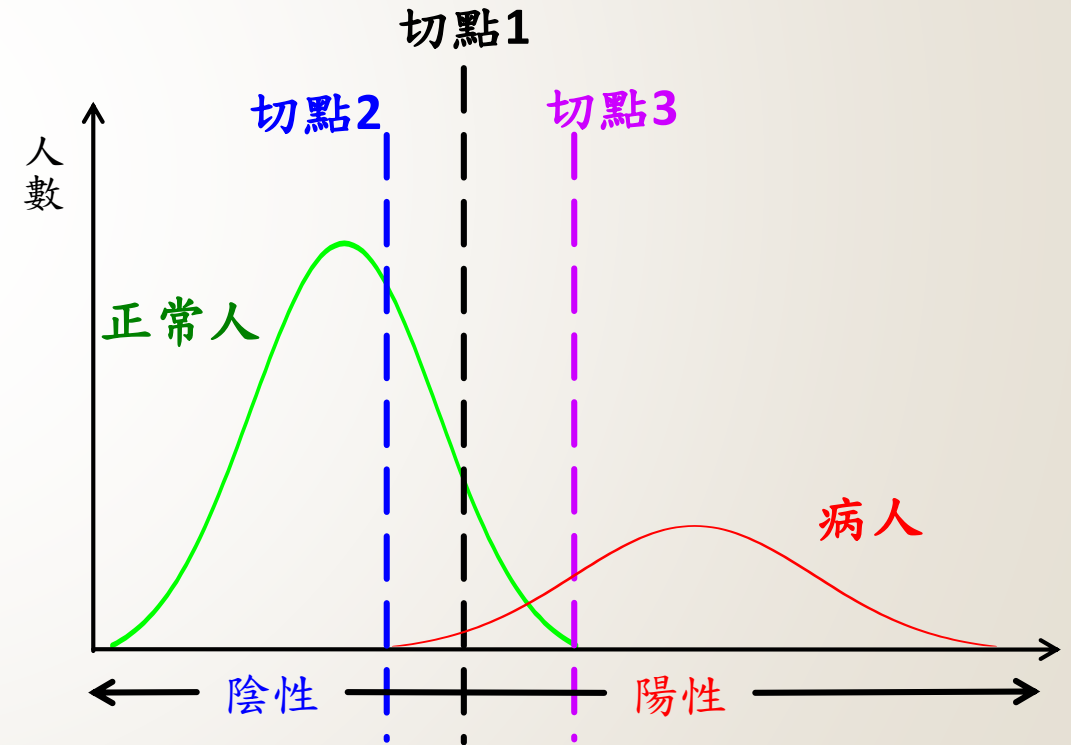
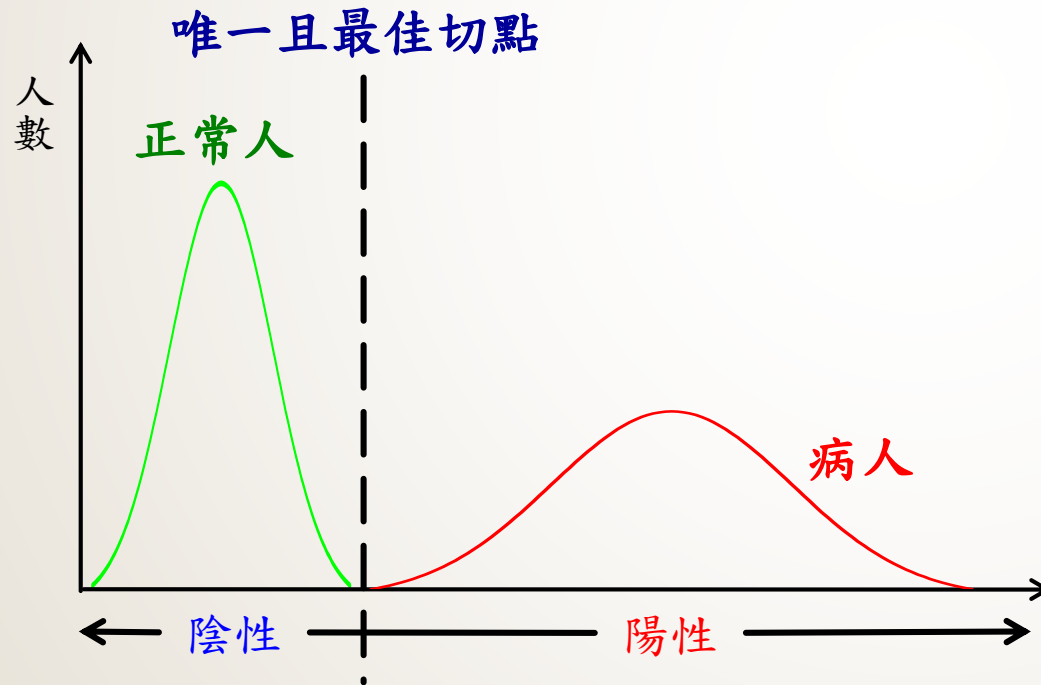
- 將連續數值決定臨界值
- 用來比較不同工具的好壞

# ROC Curve Analysis (AUC 曲線下面積)

		AUC	Discrimination
		0.5	No discrimination
		0.7-0.8 0.8-0.9	Acceptable discrimination Excellent discrimination
		0.9-1.0	Outstanding discrimination

# ROC Curve Analysis

## ► Cut-point



# ROC Curve Analysis

## ► Youden's index

► 反映在有疾病和沒有疾病的陽性結果可能機率

## ► 公式

► Sensitivity + Specificity - 1

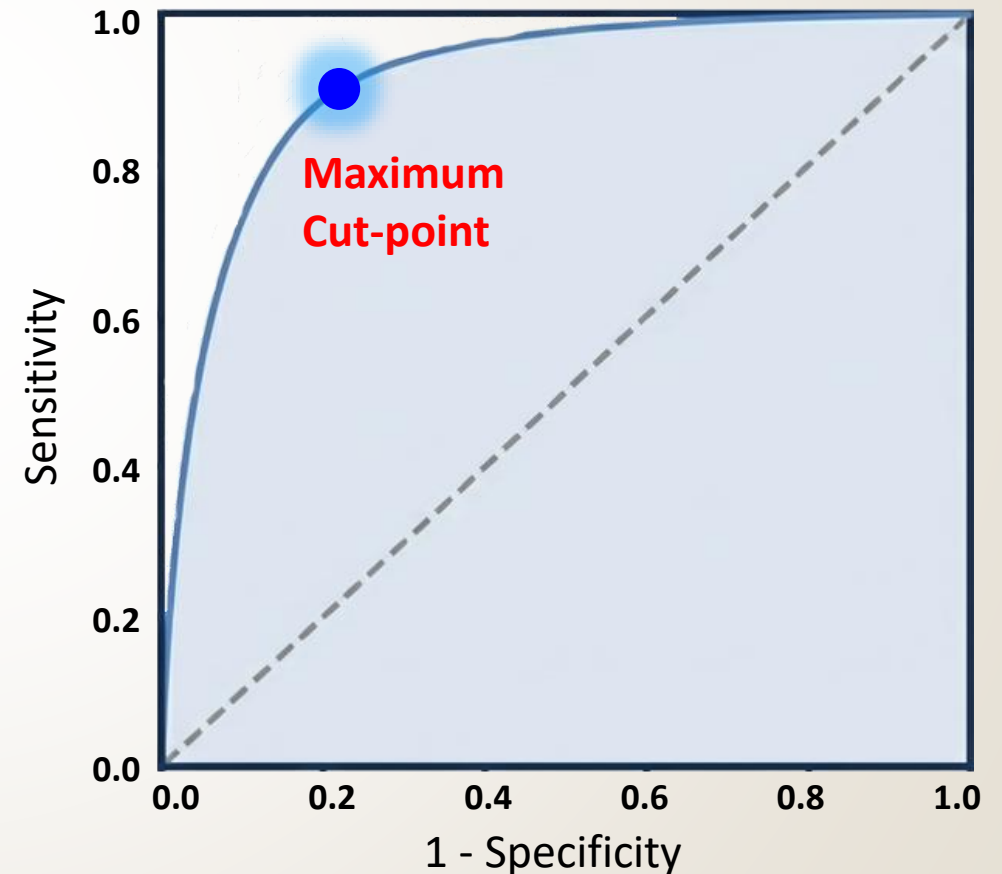
► Sensitivity - False positive

## ► Range 0-1

► 不受盛行率影響

## ► Maximum

► Cut-point



# ROC Curve Analysis

- ▶ 樣本量-分析結果推論的精確度
  - ▶ 假設：AUC = 0.8 、  $\alpha = 0.05$  、  $\beta = 0.2$
  - ▶ Medcalc計算樣本數
    - ▶ **Sampling → Area under ROC**
      - ▶ Type I error (Alpha, Significance) = 0.05
      - ▶ Type II error (Beta, 1-Power) = 0.20
      - ▶ Area under ROC curve = 0.80
      - ▶ Ratio of sample sizes in negative/positive groups = 1

# ROC Curve Analysis (MedCalc 計算樣本數)

➡ Sample size → Area under ROC curve

1 Sample size Window Help

- Single mean...
- Single proportion...
- Comparison of two means...
- Paired samples t-test...
- Comparison of two proportions...
- McNemar test...
- Correlation coefficient...
- Survival analysis (logrank test)...
- Bland-Altman plot...
- 2 Area under ROC curve...**
- Comparison of two ROC curves...
- Confidence Interval estimation & Precision

Type I error (Alpha, Significance):

Type II error (Beta, 1-Power):

0.20
0.10
<b>0.05</b>
0.025
0.01
0.005
0.001
0.0005
0.0001

0.20
<b>0.10</b>
0.05
0.025
0.01
0.005
0.001
0.0005
0.0001

Sampling: area under ROC curve

Type I and II error

Type I error (Alpha, Significance):

Type II error (Beta, 1-Power):

Input

Area under ROC curve:

Null Hypothesis value:

Ratio of sample sizes in negative / positive groups:

Results

Number of positive cases required:

Number of negative cases required:

Total sample size (both groups together):

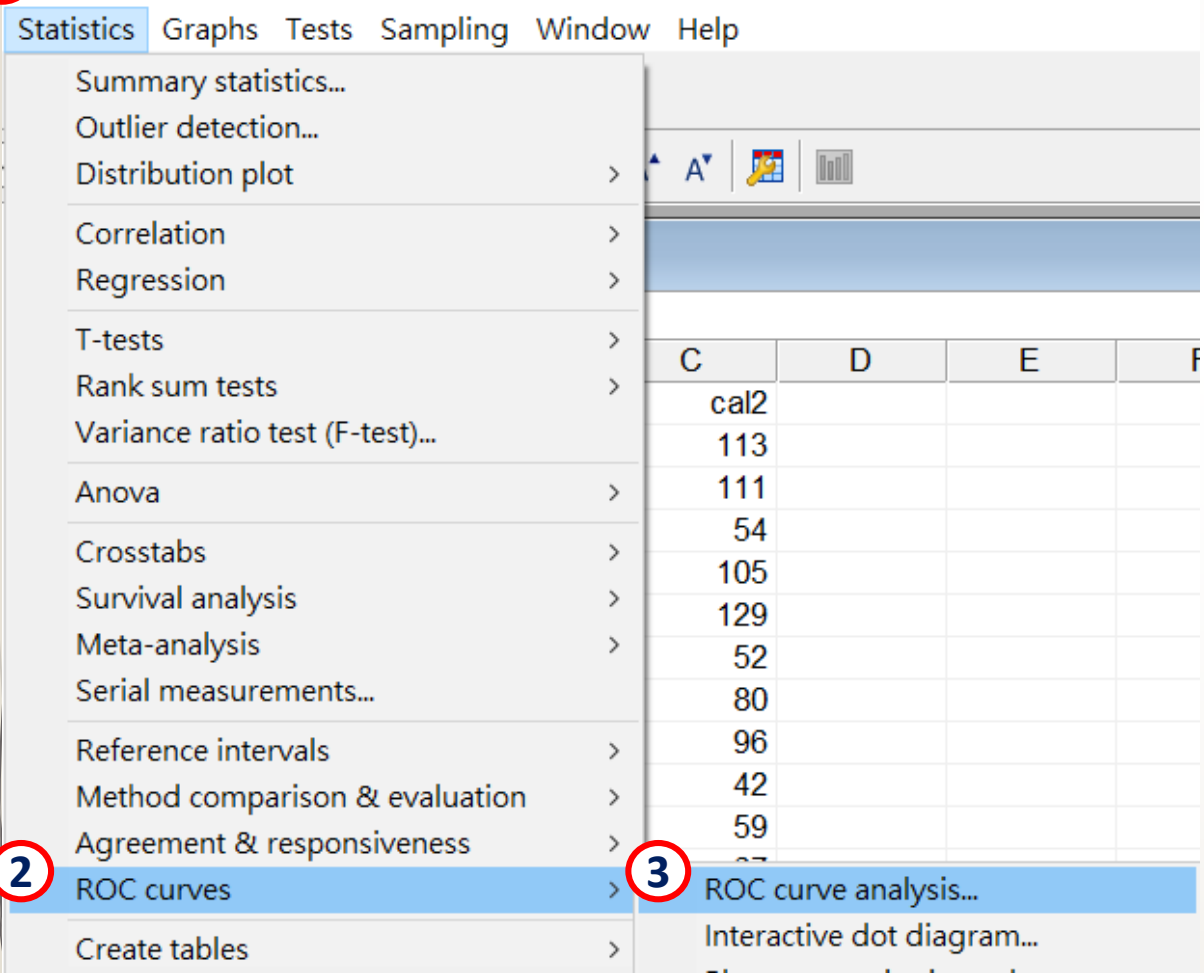
		Type I Error - Alpha			
		0.20	0.10	0.05	0.01
Type II Error - Beta	0.20	7 + 7	10 + 10	13 + 13	20 + 20
	0.10	10 + 10	13 + 13	17 + 17	24 + 24
Beta	0.05	12 + 12	16 + 16	20 + 20	28 + 28
	0.01	18 + 18	22 + 22	26 + 26	36 + 36

Calculate Exit

# ROC Curve Analysis (MedCalc)

➔ **Statistics → ROC curves → ROC Curve Analysis**

1

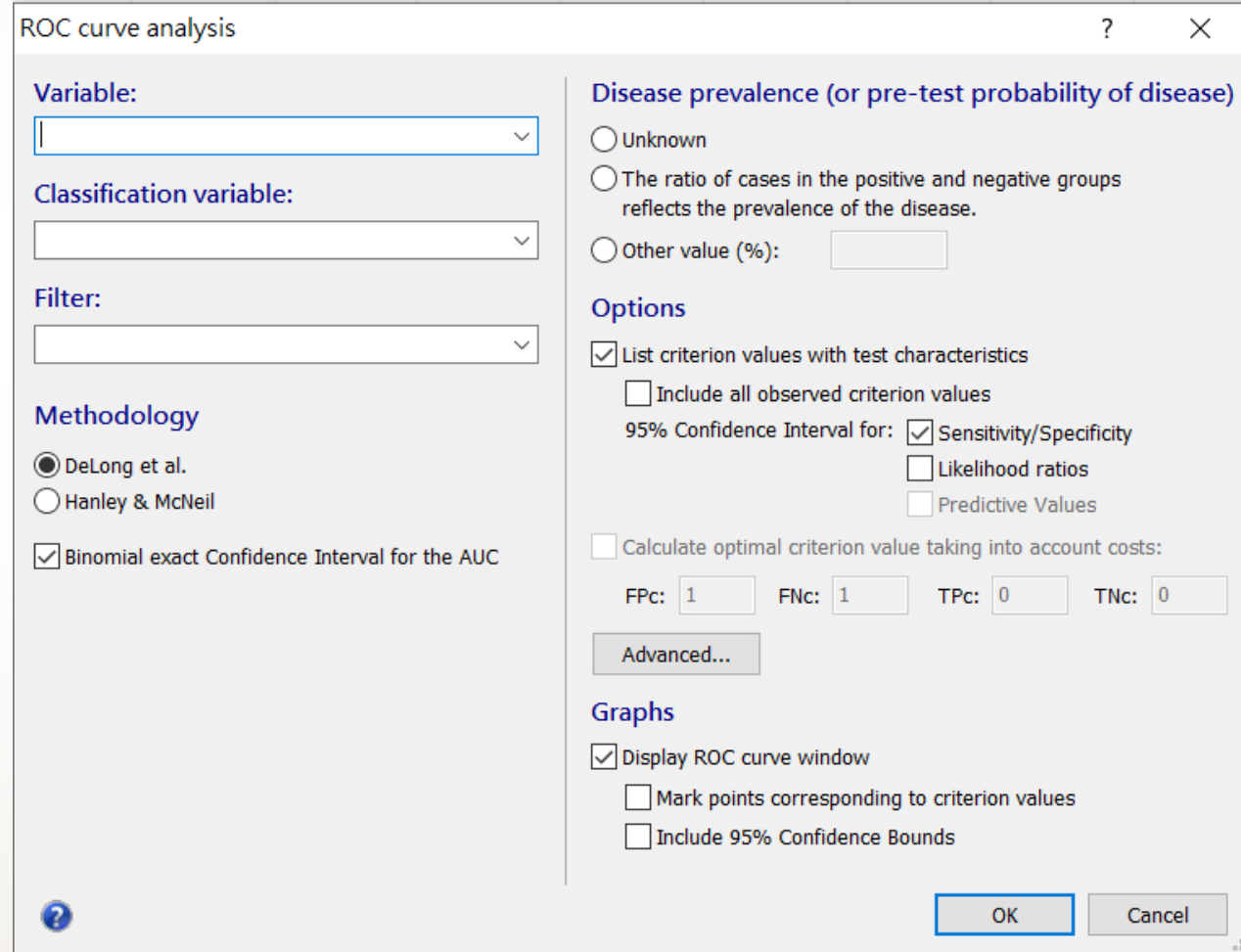


The screenshot shows the MedCalc software interface with the 'Statistics' menu open. The menu items are listed on the left, and a sub-menu is visible on the right. The 'ROC curves' option is highlighted in blue, and the 'ROC curve analysis...' option is also highlighted in blue. A red circle with the number '2' is around the 'ROC curves' option, and a red circle with the number '3' is around the 'ROC curve analysis...' option. The background shows a spreadsheet with columns C, D, E, and F, and rows containing data for 'cal2'.

	C	D	E	F
	cal2			
	113			
	111			
	54			
	105			
	129			
	52			
	80			
	96			
	42			
	59			

2

3



The screenshot shows the 'ROC curve analysis' dialog box in MedCalc. The dialog box has several sections: 'Variable:', 'Classification variable:', 'Filter:', 'Methodology', 'Disease prevalence (or pre-test probability of disease)', 'Options', and 'Graphs'. The 'Variable:' field is empty. The 'Classification variable:' field is empty. The 'Filter:' field is empty. The 'Methodology' section has radio buttons for 'DeLong et al.' (selected), 'Hanley & McNeil', and a checked box for 'Binomial exact Confidence Interval for the AUC'. The 'Disease prevalence' section has radio buttons for 'Unknown', 'The ratio of cases in the positive and negative groups reflects the prevalence of the disease.', and 'Other value (%)' with an empty text box. The 'Options' section has a checked box for 'List criterion values with test characteristics', and sub-options for 'Include all observed criterion values', '95% Confidence Interval for:' (with checked boxes for 'Sensitivity/Specificity', 'Likelihood ratios', and 'Predictive Values'), and 'Calculate optimal criterion value taking into account costs:'. The 'Graphs' section has a checked box for 'Display ROC curve window', and sub-options for 'Mark points corresponding to criterion values' and 'Include 95% Confidence Bounds'. The 'Advanced...' button is visible. The 'OK' and 'Cancel' buttons are at the bottom right.

# ROC Curve Analysis (MedCalc)

Statistics → ROC curves → ROC Curve Analysis

4

ROC curve analysis

Variable: cal1

Classification variable: alive

Methodology:  DeLong et al.

Binomial exact Confidence Interval for the AUC

Disease prevalence (or pre-test probability of disease):  Unknown

Options:  List criterion values with test characteristics

Graphs:  Display ROC curve window

ROC curve

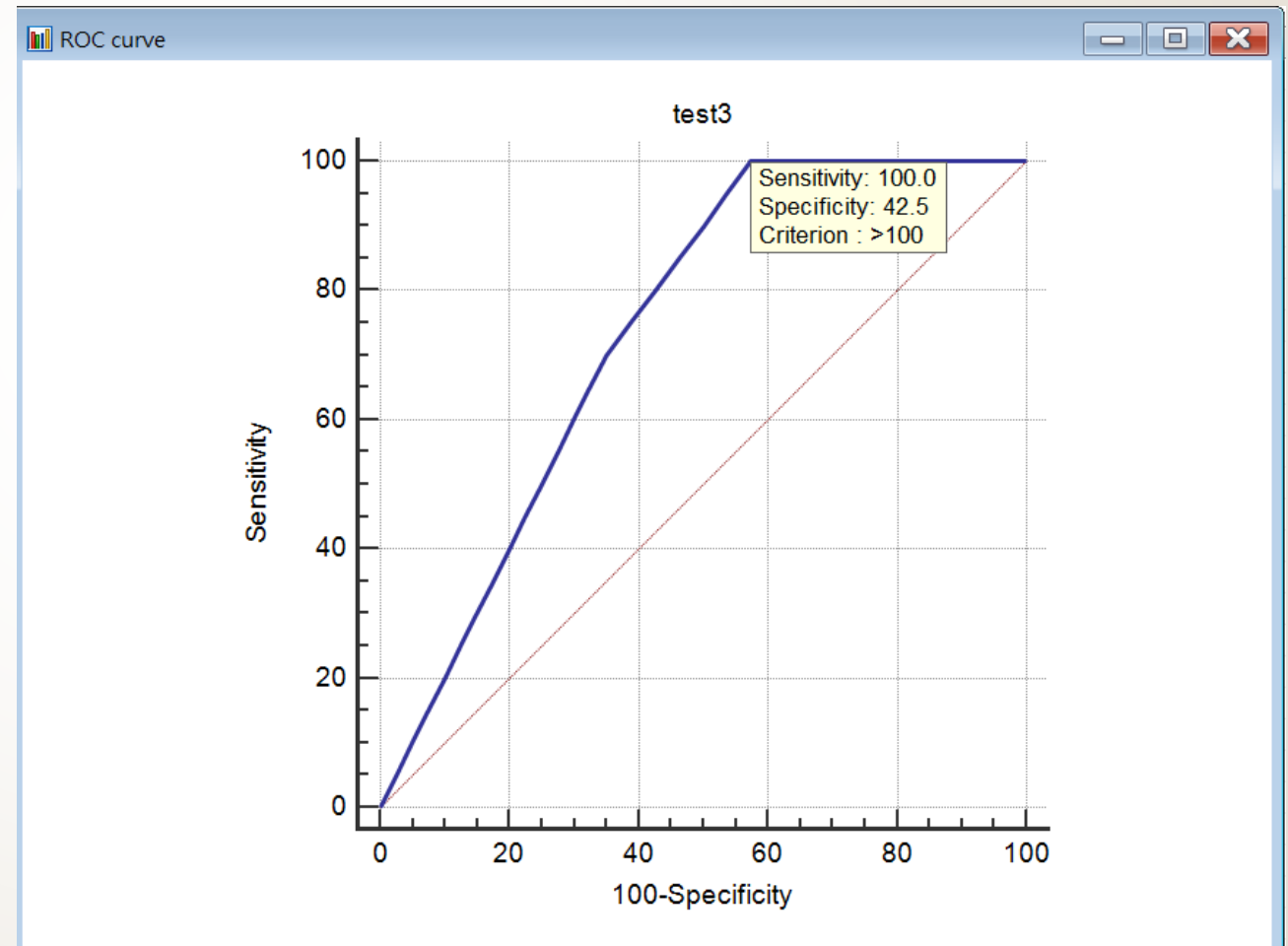
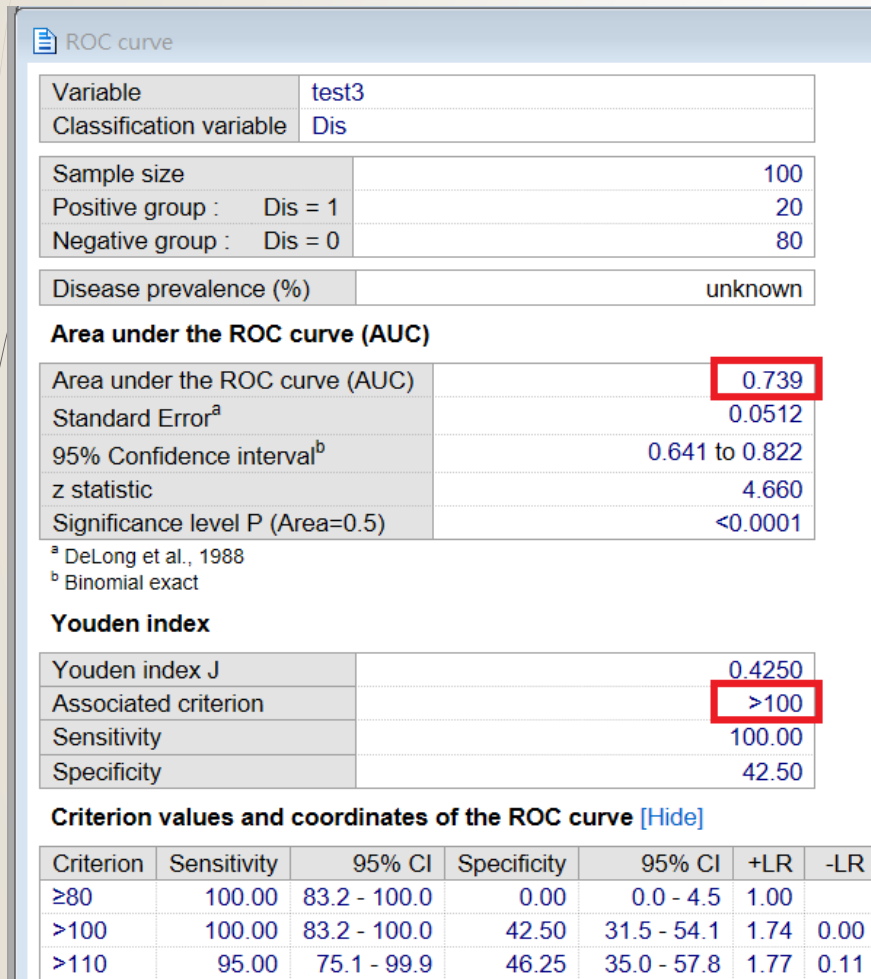
Variable	cal1					
Classification variable	alive					
Sample size	55					
Positive group : alive = 1	30					
Negative group : alive = 0	25					
Disease prevalence (%)	unknown					
<b>Area under the ROC curve (AUC)</b>						
Area under the ROC curve (AUC)	0.729					
Standard Error <sup>a</sup>	0.0699					
95% Confidence interval <sup>b</sup>	0.593 to 0.840					
z statistic	3.283					
Significance level P (Area=0.5)	0.0010					
<b>Youden index</b>						
Youden index J	0.4000					
Associated criterion	>65					
Sensitivity	60.00					
Specificity	80.00					
<b>Criterion values and coordinates of the ROC curve [Hide]</b>						
Criterion	Sensitivity	95% CI	Specificity	95% CI	+LR	-LR
≥6	100.00	88.4 - 100.0	0.00	0.0 - 13.7	1.00	
>16	100.00	88.4 - 100.0	8.00	1.0 - 26.0	1.09	0.00
>19	96.67	82.8 - 99.9	12.00	2.5 - 31.2	1.10	0.28
>35	96.67	82.8 - 99.9	40.00	21.1 - 61.3	1.61	0.083
>20	60.00	37.0 - 80.2	40.00	21.1 - 61.3	1.66	0.17

ROC curve

Sensitivity: 60.0  
Specificity: 80.0  
Criterion: >65

# ROC Curve Analysis (MedCalc)

► Statistics → ROC curves → ROC Curve Analysis



# ROC Curve Analysis (MedCalc)

➔ Statistics → ROC curves → ROC Curve Analysis

ROC curve analysis

Variable: test3

Classification variable: Dis

Filter:

Methodology

DeLong et al.

Hanley & McNeil

Binomial exact Confidence Interval for the AUC

Disease prevalence (or pre-test probability of disease)

Unknown

The ratio of cases in the positive and negative groups reflects the prevalence of the disease.

Other value (%): 20

Options

List criterion values with test characteristics

Include all observed criterion values

95% Confidence Interval for:  Sensitivity/Specificity  Likelihood ratios  Predictive Values

Calculate optimal criterion value taking into account costs:

FPc: 1 FNC: 1 TPC: 0 TNC: 0

Advanced...

Graphs

Display ROC curve window

Mark points corresponding to criterion values

Include 95% Confidence Bounds

OK Cancel

ROC curve

Sample size	100
Positive group : Dis = 1	20
Negative group : Dis = 0	80
Disease prevalence (%)	20

**Area under the ROC curve (AUC)**

Area under the ROC curve (AUC)	0.739
Standard Error <sup>a</sup>	0.0512
95% Confidence interval <sup>b</sup>	0.641 to 0.822
z statistic	4.660
Significance level P (Area=0.5)	<0.0001

<sup>a</sup> DeLong et al., 1988  
<sup>b</sup> Binomial exact

**Youden index**

Youden index J	0.4250
Associated criterion	>100
Sensitivity	100.00
Specificity	42.50

# ROC Curve Analysis (MedCalc)

► Statistics → ROC curves → ROC Curve Analysis

Criterion values and coordinates of the ROC curve [Hide]

Criterion	Sensitivity	95% CI	Specificity	95% CI	+LR	95% CI	-LR	95% CI	+PV	95% CI	-PV	95% CI
≥80	100.00	83.2 - 100.0	0.00	0.0 - 4.5	1.00	1.0 - 1.0			20.0	12.7 - 29.2		
>80	100.00	83.2 - 100.0	2.50	0.3 - 8.7	1.03	1.0 - 1.1	0.00		20.4	12.9 - 29.7	100.0	15.8 - 100.0
>82	100.00	83.2 - 100.0	5.00	1.4 - 12.3	1.05	1.0 - 1.1	0.00		20.8	13.2 - 30.3	100.0	39.8 - 100.0
>84	100.00	83.2 - 100.0	7.50	2.8 - 15.6	1.08	1.0 - 1.2	0.00		21.3	13.5 - 30.9	100.0	54.1 - 100.0
>86	100.00	83.2 - 100.0	10.00	4.4 - 18.8	1.11	1.0 - 1.2	0.00		21.7	13.8 - 31.6	100.0	63.1 - 100.0
>88	100.00	83.2 - 100.0	12.50	6.2 - 21.8	1.14	1.1 - 1.2	0.00		22.2	14.1 - 32.2	100.0	69.2 - 100.0
>90	100.00	83.2 - 100.0	17.50	9.9 - 27.6	1.21	1.1 - 1.3	0.00		23.3	14.8 - 33.6	100.0	76.8 - 100.0
>92	100.00	83.2 - 100.0	22.50	13.9 - 33.2	1.29	1.1 - 1.5	0.00		24.4	15.6 - 35.1	100.0	81.5 - 100.0
>94	100.00	83.2 - 100.0	27.50	18.1 - 38.6	1.38	1.2 - 1.6	0.00		25.6	16.4 - 36.8	100.0	84.6 - 100.0
>96	100.00	83.2 - 100.0	32.50	22.4 - 43.9	1.48	1.3 - 1.7	0.00		27.0	17.4 - 38.6	100.0	86.8 - 100.0
>98	100.00	83.2 - 100.0	37.50	26.9 - 49.0	1.60	1.4 - 1.9	0.00		28.6	18.4 - 40.6	100.0	88.4 - 100.0
>100	100.00	83.2 - 100.0	42.50	31.5 - 54.1	1.74	1.4 - 2.1	0.00		30.3	19.6 - 42.9	100.0	89.7 - 100.0
>110	95.00	75.1 - 99.9	46.25	35.0 - 57.8	1.77	1.4 - 2.2	0.11	0.02 - 0.7	30.6	19.6 - 43.7	97.4	86.2 - 99.9
>112	90.00	68.3 - 98.8	50.00	38.6 - 61.4	1.80	1.4 - 2.3	0.20	0.05 - 0.8	31.0	19.5 - 44.5	95.2	83.8 - 99.4

# ROC Curve Analysis (MedCalc)

➔ **Statistics** → **ROC curves** → **Comparison of ROC Curves**

1

Statistics | Graphs | Tests | Sampling | Window | Help

- Summary statistics...
- Outlier detection...
- Distribution plot >
- Correlation >
- Regression >
- T-tests >
- Rank sum tests >
- Variance ratio test (F-test)...
- Anova >
- Crosstabs >
- Survival analysis >
- Meta-analysis >
- Serial measurements...
- Reference intervals >
- Method comparison & evaluation >
- Agreement & responsiveness >
- ROC curves >**
  - ROC curve analysis...
  - Interactive dot diagram...
  - Plot versus criterion values...
  - Predictive values...
  - Interval likelihood ratios...
  - Comparison of ROC curves...**
- Create tables >

	C	D	E	F
	test2	test3		
	110	110		
	112	112		
	114	114		
	116	116		
	118	118		
	120	120		
	122	122		
	124	124		
	126	126		
	128	128		
	130	130		
	132	132		
	134	134		
	136	136		
	138	138		
	140	140		
	142	142		
	144	144		

2

3

Comparison of ROC curves

Variables:

- [Empty dropdown]
- [Empty dropdown]
- [Empty dropdown]
- [Empty dropdown]
- [Empty dropdown]
- [Empty dropdown]

Classification variable:

- [Empty dropdown]

Filter:

- [Empty dropdown]

Methodology

- DeLong et al.
- Hanley & McNeil
- Binomial exact Confidence Interval for the AUC

Graph

- Display ROC curves window
- Mark points corresponding to criterion values

OK Cancel

# ROC Curve Analysis (MedCalc)

➔ Statistics → ROC curves → Comparison of ROC Curves

Comparison of ROC curves

Variables:  
 test1  
 test2  
 test3

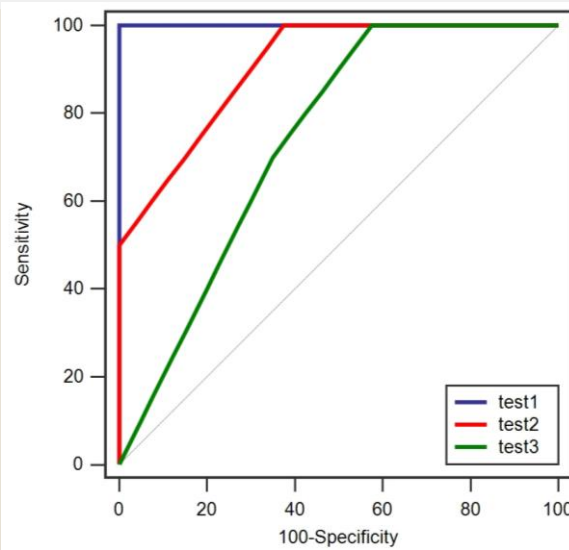
Methodology  
 DeLong et al.  
 Hanley & McNeil  
 Binomial exact Confidence Interval for the AUC

Graph  
 Display ROC curves window  
 Mark points corresponding to criterion values

Classification variable:  
 Dis

Filter:

OK Cancel



Variable 1	test1
Variable 2	test2
Variable 3	test3
Classification variable	Dis
Sample size	100
Positive group : Dis = 1	20
Negative group : Dis = 0	80

	AUC	SE <sup>a</sup>	95% CI <sup>b</sup>
test1	1.000	0.000	0.964 to 1.000
test2	0.906	0.0324	0.831 to 0.955
test3	0.739	0.0512	0.641 to 0.822

<sup>a</sup> DeLong et al., 1988

<sup>b</sup> Binomial exact

## Pairwise comparison of ROC curves

test1 ~ test2	
Difference between areas	0.0937
Standard Error <sup>c</sup>	0.0324
95% Confidence Interval	0.0302 to 0.157
z statistic	2.892
Significance level	P = 0.0038

test1 ~ test3	
Difference between areas	0.261
Standard Error <sup>c</sup>	0.0512
95% Confidence Interval	0.161 to 0.362
z statistic	5.099
Significance level	P < 0.0001

test2 ~ test3	
Difference between areas	0.168
Standard Error <sup>c</sup>	0.0349
95% Confidence Interval	0.0991 to 0.236
z statistic	4.797
Significance level	P < 0.0001

<sup>c</sup> DeLong et al., 1988

# ROC Curve Analysis (SPSS)

➔ Analyze → ROC curve

**1** Analyze → Direct Marketing → Graphs → ROC Curve

**2** ROC Curve

Test Variable:

State Variable:

Value of State Variable:

Display

- ROC Curve
- With diagonal reference line
- Standard error and confidence interval
- Coordinate points of the ROC Curve

OK Paste Reset Cancel Help

**3** ROC Curve

Test Variable: Energy\_1 [cal1]

State Variable: Alive [alive]

Value of State Variable: 1

Display

- ROC Curve
- With diagonal reference line
- Standard error and confidence interval
- Coordinate points of the ROC Curve

OK Paste Reset Cancel Help

# ROC Curve Analysis (SPSS)

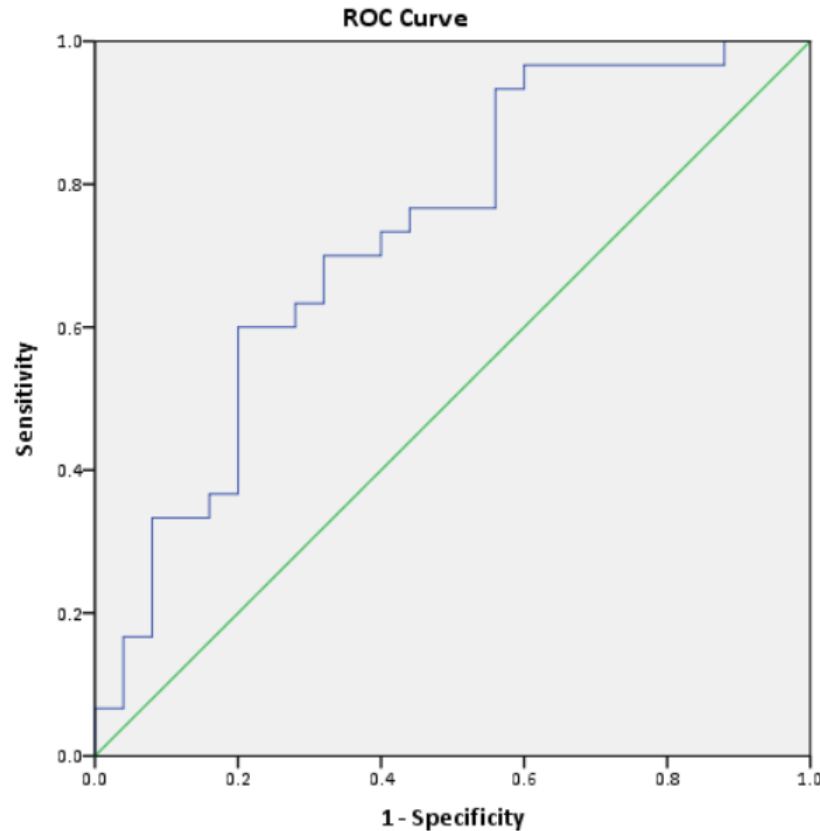
## ROC Curve

### Case Processing Summary

	Valid N (listwise)
Alive	
Positive <sup>a</sup>	30
Negative	25

Larger values of the test result variable(s) indicate stronger evidence for a positive actual state.

a. The positive actual state is Alive.



## Area Under the Curve

Test Result Variable(s): Energy\_1

Area	Std. Error <sup>a</sup>	Asymptotic Sig. <sup>b</sup>	Asymptotic 95% Confidence Interval	
			Lower Bound	Upper Bound
.729	.069	.004	.594	.865

a. Under the null hypothesis

b. Null hypothesis

Co

Test Result Var

Positive if Greater Than or Equal To <sup>a</sup>	Sensitivity	1 - Specificity
4.82	1.000	1.000
10.68	1.000	.960
17.07	1.000	.920
18.76	1.000	.880
21.61	.967	.880
24.43	.967	.840
25.66	.967	.800

**AUC = 0.73**  
**(0.59-0.87)**  
**Acceptable discrimination**

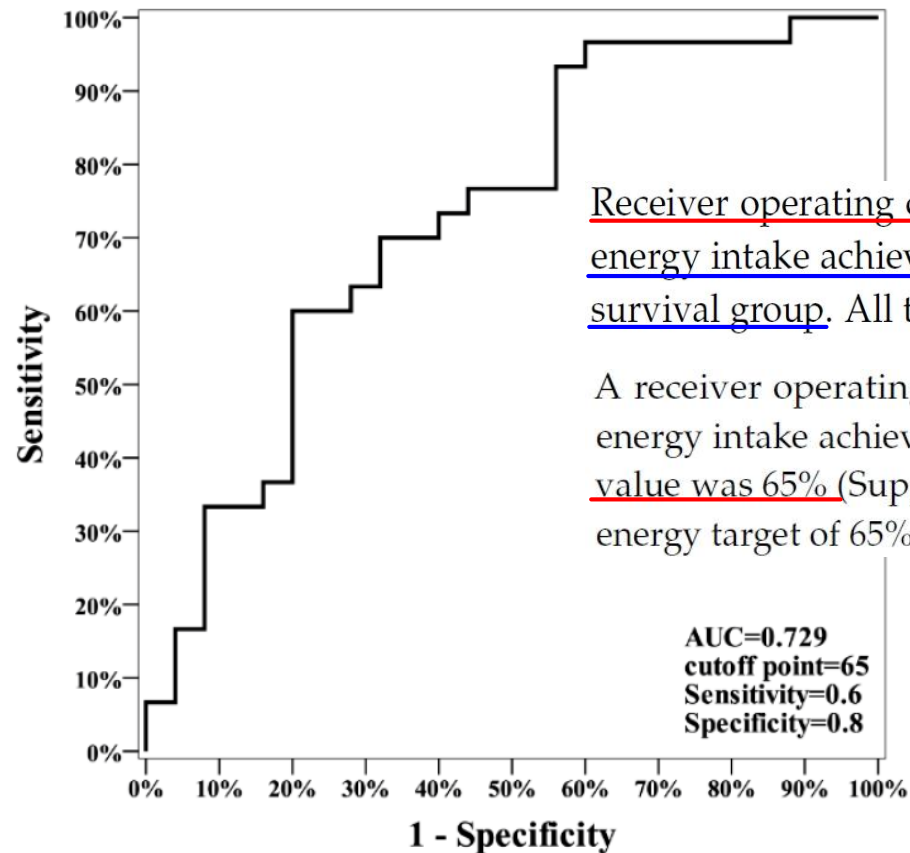
# ROC Curve Analysis (SPSS & Excel)

- Cut-point
  - Youden's index (Maximum)
    - Sensitivity + Specificity - 1

	A	B	C	D	E
1	Coordinates of the Curve				
2	Test Result Variable(s):				
3	Positive if Greater Than or Equal To <sup>a</sup>	Sensitivity	1-Specificity	Specificity	Youden's index
4	65.22	.600	.200	0.800	=B4+D4-1
5	54.90	.700	.320	0.680	0.380
6	40.99	.933	.560	0.440	0.373
7	36.66	.967	.600	0.400	0.367
8	66.28	.567	.200	0.800	0.367
9	64.15	.600	.240	0.760	0.360
10	60.46	.633	.280	0.720	0.353
11	55.91	.667	.320	0.680	0.347
12	41.64	.900	.560	0.440	0.340
13	53.00	.700	.360	0.640	0.340
14	39.65	.933	.600	0.400	0.333
15	66.95	.533	.200	0.800	0.333

# Reference

## Supplementary Materials



Receiver operating characteristic (ROC) curves were used to evaluate the discriminative ability of energy intake achievement rates on day 3 after the initiation of small bowel feeding to identify the survival group. All tests were two-sided, with  $p < 0.05$  considered significant.

A receiver operating characteristic (ROC) curve was used to evaluate the discriminative ability of energy intake achievement rates 3 days after SBEN initiation to identify the survival group; the cutoff value was 65% (Supplement Figure S1). In the survival group, two-thirds of the patients achieved the energy target of 65%.

**Figure 1.** Receiver operating characteristic (ROC) curve to determine the cutoff point for the feeding target between surviving and non-surviving malnourished patients administered SBEN.

# Reference

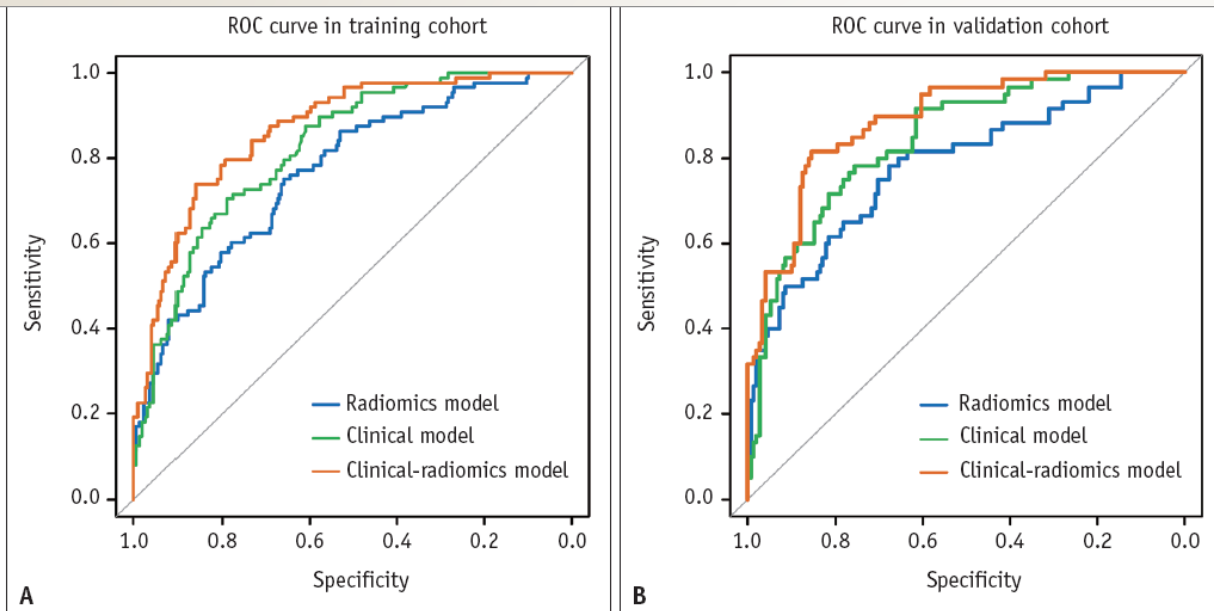


Fig. 2. ROC curves of the radiomics model, clinical model, and clinical-radiomics model in the training (A) and validation (B) cohorts. ROC = receiver operating characteristic

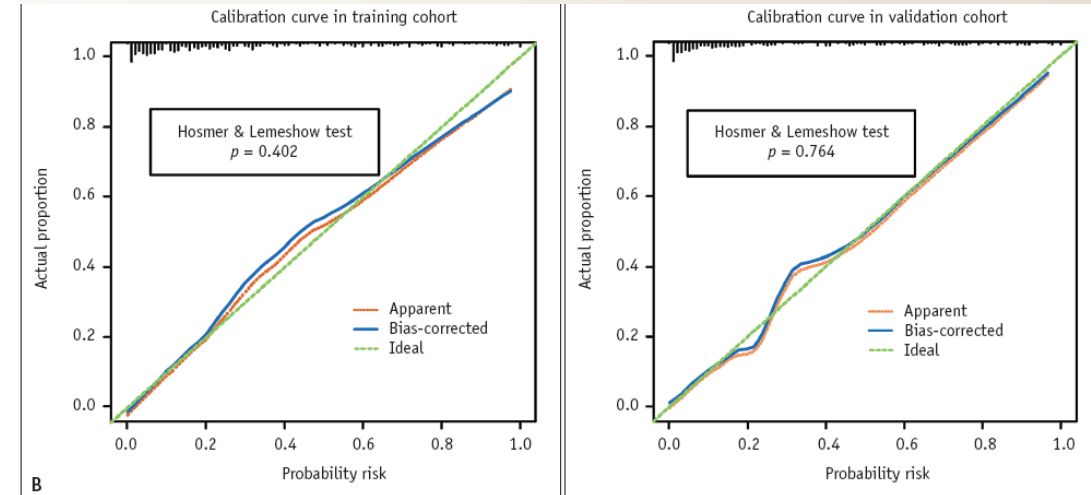


Fig. 3. The clinical-radiomics nomogram for predicting acute ischemic stroke outcomes.

A. The developed nomogram based on the clinical-radiomics prediction model to predict the risk of poor stroke outcome. Diabetes: 0, no diabetes; 1, diabetes. Sex: 0, female; 1, male. Stroke history: 0, no stroke history; 1, stroke history;  $mRS_{baseline}$ : 0,  $\leq 2$ ; 1,  $> 2$ . B. Calibration curves for the nomogram in the training and validation cohorts. The green dashed line represents the ideal prediction and the red dashed line represents the predictive ability of the nomogram. The closer the dashed red line fit to the dashed green line, the greater the prediction accuracy of the nomogram. C. Decision curve analysis for the nomogram. The black line represents the net benefit of assuming no stroke patients have

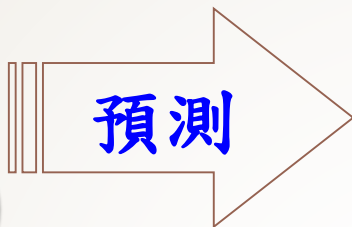
The predictive performance of the radiomics, clinical, and clinical-radiomics models was evaluated using **receiver operating characteristic (ROC) curves**. The area under the ROC curve (**AUC**) and balanced **sensitivity** and **specificity** at the cutoff yielding the largest **Youden index** value were calculated. The performance of the three models was tested in the training and validation cohorts. The Delong test was used to compare the AUC between the models.

The calibration curve and **Hosmer–Lemeshow test** were used to assess the calibration performance of the clinicalradiomics nomogram.

# 總結

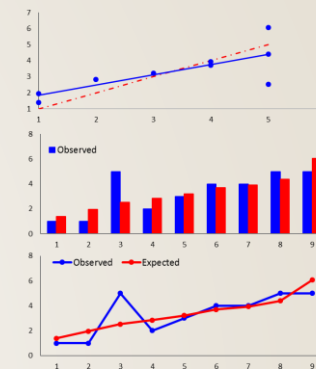


**X**  
(模型)



**Y**  
(事件機率)

Hosmer and Lemeshow test



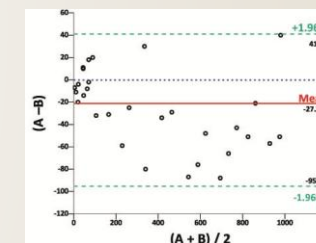
Agreement

quantitative  
Method A



quantitative  
Method B

Bland-Altman plot

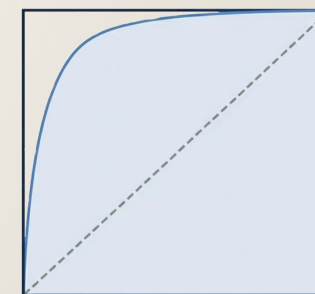


Discrimination



檢驗方法  
(診斷工具)

ROC curve



生統小組  
統計方法教育訓練



# Thank you

問卷調查



# For your attention!!