世代研究的描述性統計 (2)

醫學研究部生統小組

陳俊朋

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醫學研究常用統計

Table 2. Percentage of articles in corpus (N = 113,450) citing the following 16 Delphi panel–derived statistical methods groups

Method groups	Percentage of articles citing specific method group overall and by strata				Relative percent change in method group over time[a]			Examples of commonly occurring terms in each statistical method group
	Overall[b]	95-05[c]	06-10[d]	11-15[e]	06-10 vs. 95-05[f]	11-15 vs. 06-10[g]	11-15 vs. 95-05[h]	
Numeric summary measures	96.4	92.8	96.4	96.8	3.9	0.4	4.3	Average, mode, percentage, standard deviation
Epidemiological measures of risk/effect	53.5	38.0	52.3	55.7	37.5	6.5	46.5	Prevalence, incidence, odds ratio, hazard ratio
Statistical inference concepts	52.9	36.4	52.1	55.0	43.2	5.7	51.4	*P*-value, confidence interval, multiple comparisons
Epidemiological concepts of classification	40.1	43.7	39.8	39.9	−9.0	0.2	−8.8	Sensitivity, specificity, ROC curve
Specific hypothesis test	28.8	23.8	29.0	29.2	21.8	0.7	22.7	*t*-test, Fisher exact test, chi-square test
ANOVA	23.2	14.9	22.2	24.4	49.0	9.8	63.6	ANOVA, ANCOVA, RMANOVA
Regression	22.6	11.9	21.6	24.1	82.1	11.5	103.0	Linear, logistic, poisson regression
Graphics	8.8	8.5	8.7	8.8	2.7	1.3	4.0	Histogram, scatter plot, box plot
Survival analysis	6.8	3.0	6.6	7.3	123.2	11.0	147.6	Cox regression, Kaplan–Meier
Missing data	6.8	2.4	5.9	7.6	148.4	28.0	217.9	Missing data, multiple imputation, LOCF
Computationally intensive algorithms	6.3	3.8	6.2	6.5	63.5	4.5	70.9	Simulation, bootstrap, Monte Carlo, MCMC
Multivariate methods	5.9	3.1	5.5	6.4	73.6	16.6	102.5	Cronbach α, factor analysis, PCA, cluster analysis
Correlated data analysis	4.1	1.6	3.7	4.6	137.3	23.1	192.2	GEE, LMM, GLMM, multilevel model
Machine learning	3.1	1.8	3.0	3.3	66.0	9.9	82.5	Lasso, wavelet, neural network
Time series	1.4	0.9	1.3	1.5	48.8	12.0	66.7	ARIMA, forecasting, spectral analysis
Causal inference observational studies	1.0	0.2	0.8	1.2	268.3	57.8	481.2	Propensity score, instrumental variable

Meaney, Christopher, et al. Journal of clinical epidemiology 74 (2016): 124-132

Data type/Statistical method

Data type	Two group		Three group	Correlation
	獨立樣本	相依樣本	獨立樣本	
Continuous				
-Parametric	Independent T-test	Paired T-test	ANOVA	Pearson correlation
-Non-parametric	Mann-Whitney U test	Wilcoxon signed-rank test	Kruskal-Wallis test	Spearman rank correlation

Mean / Median

- 平均數易受到極端值的影響

- 無母數原理

Case No	Height	Rank	Group
1	212	9	1
2	151	1	1
3	155	4	1
4	159	8	1
5	152	2	2
6	153	3	2
7	156	5	2
8	157	6	2
9	158	7	2

Parametric vs Non-parametric test

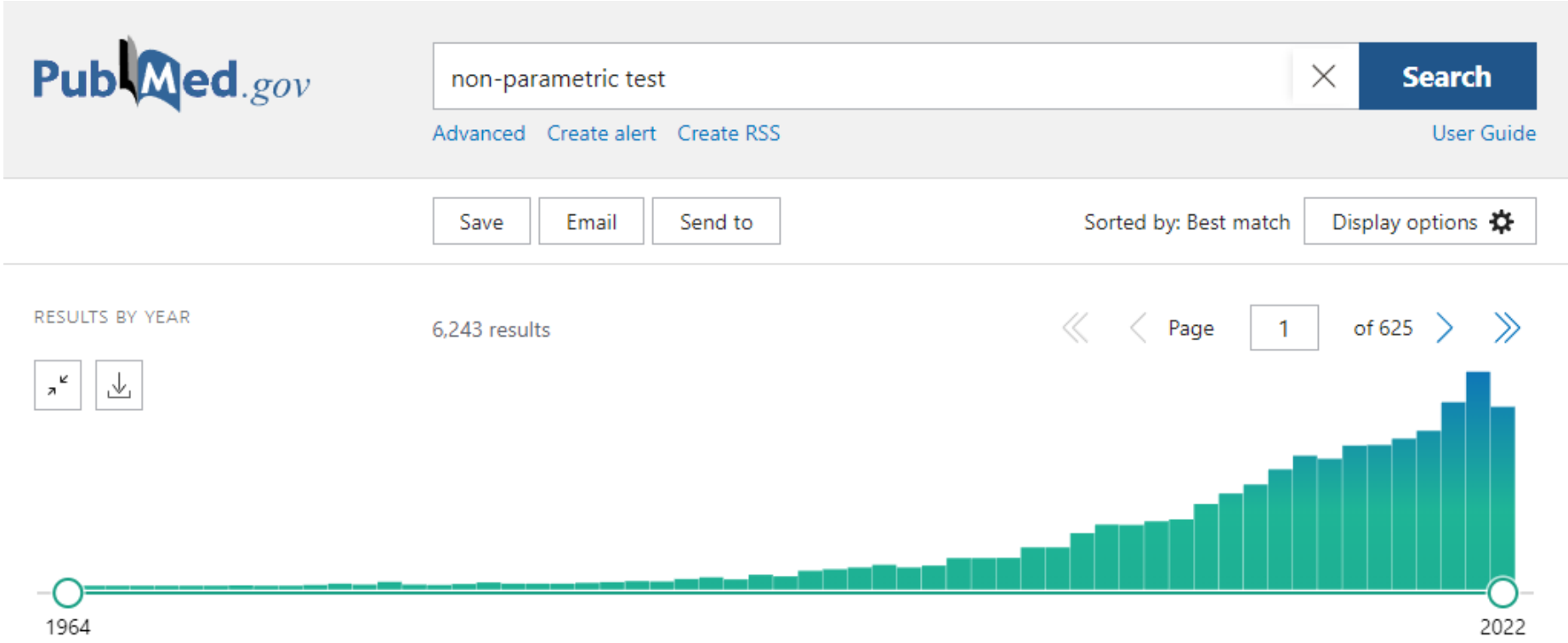
Parametric test

- 優點
  - Power較高
  - 以真實觀察值統計
- 限制
  - 需要常態分佈
  - 樣本數大
  - 容易有測量誤差

Non-parametric test

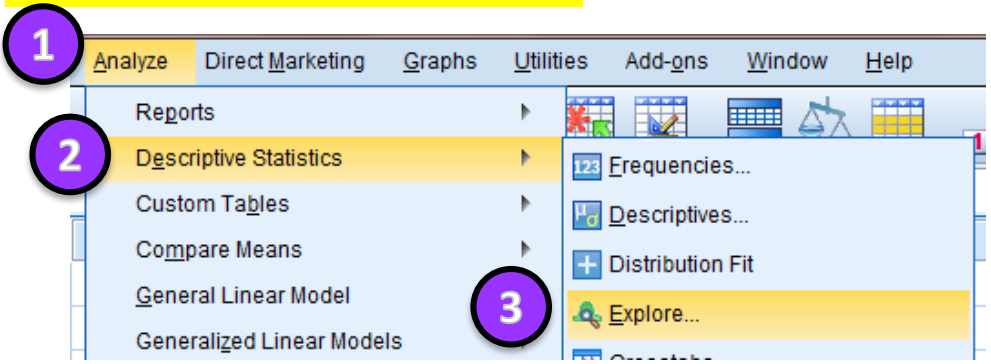
- 優點
  - 不需要為常態分佈
  - 樣本數小
  - 對於測量誤差較不敏感
- 限制
  - Power較低，且需要較多樣本數才能達顯著差異
  - 計算依據Rank而非真實數值

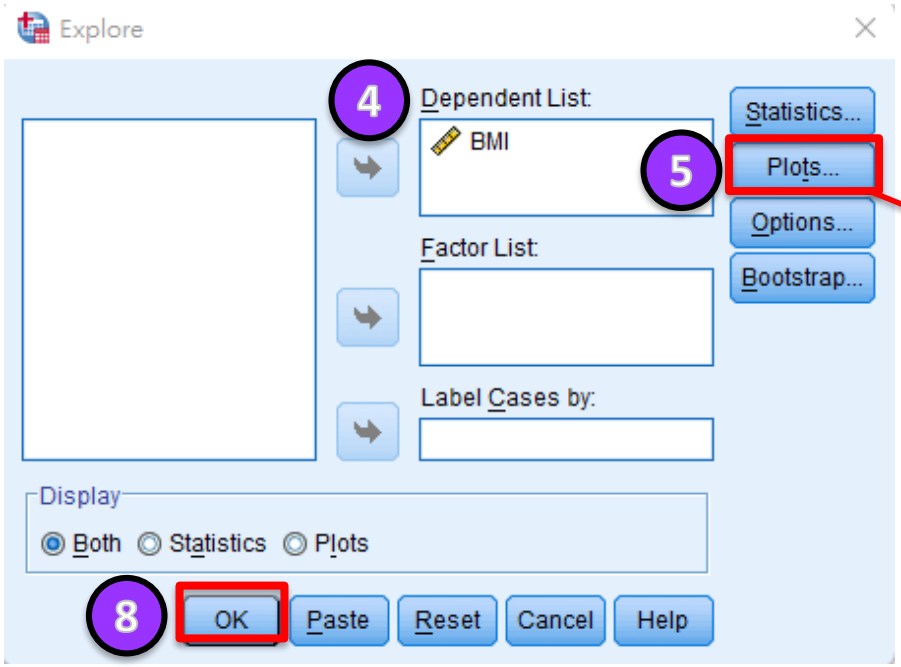
Pubmed non-parametric test



Test of Normality

分析>描述性統計>探索





For N > 50

For N < 50

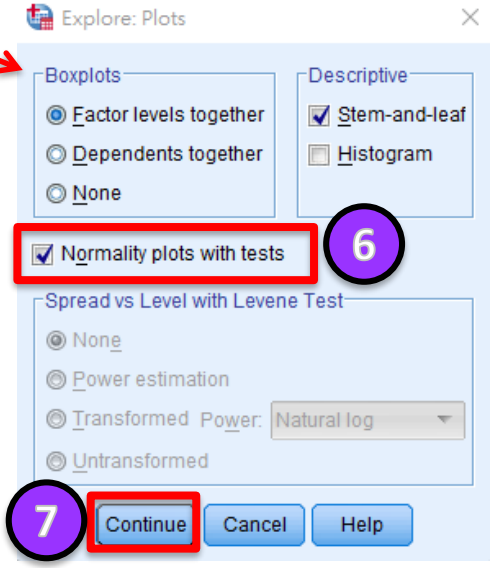
Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
BMI	.076	40	.200*	.981	40	.710

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

$p<0.05$ 代表資料呈非常態分佈



One-sample T test

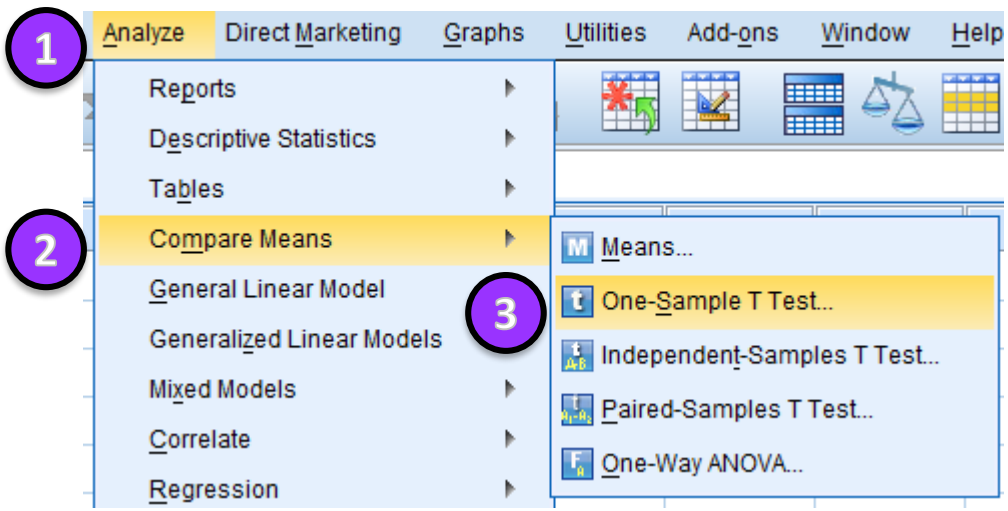
- 單組且資料呈常態分佈
- 比較單組樣本平均數和已知母體平均數的差異

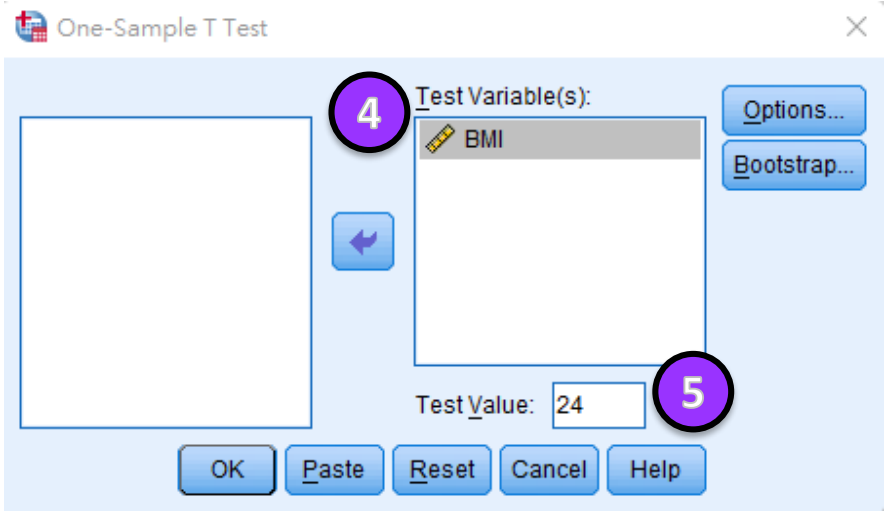
- Example
  - 收集40名個案的BMI，假設母體的BMI為 24 kg/m^2，請問BMI是否和母體的分佈相同?

	BMI
1	23.68
2	23.98
3	23.72
4	21.98
5	23.79
6	25.48
7	24.28
8	23.75
9	23.74
10	23.92
11	22.86
12	22.03

One-sample T test SPSS analysis

分析>比較平均數法>單一樣本T檢定





One-sample T test output

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
BMI	40	23.6725	.88432	.13982

One-Sample Test

	Test Value = 24					
	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
BMI	-2.342	39	.024	-.32750	-.6103	-.0447

40名個案的BMI與母體的BMI有差異且達統計顯著差異(p=0.024)

Two group-獨立樣本

Independent T-test

- 檢定兩組的平均數是否有顯著不同
- 資料需符合常態分佈

Mann-Whitney U test

- 檢定兩組的中位數是否有顯著不同
- 小樣本且資料不符合常態分佈

Independent T-test example

- Independent variable： Male and Female (Two groups)
- Dependent variable ： BMI、Height and Weight…. (Continuous)

Table 1
Demographic data of study participants

	Total (n=29164)	Male (n=12331)	Female (n=16833)	p value
	n%	n%	n%	
BMI (n=25747)	25.20±45.15	24.57±3.98	25.67±59.33	0.041*
Height (cm)	156.72±8.79	163.40±7.03	151.82±6.39	<0.001**
Weight (kg)	60.70±10.64	65.60±10.25	57.11±9.41	<0.001**
Waist circumference (cm)	84.16±9.72	86.99±9.24	82.09±9.54	<0.001**
SBP (mmHg)	134.77±19.23	134.59±18.95	134.90±19.44	0.178
DBP (mmHg)	77.78±11.62	78.30±11.68	77.40±11.56	<0.001**
Pulse pressure (mmHg)	56.99±14.61	56.29±14.33	57.49±14.78	<0.001**

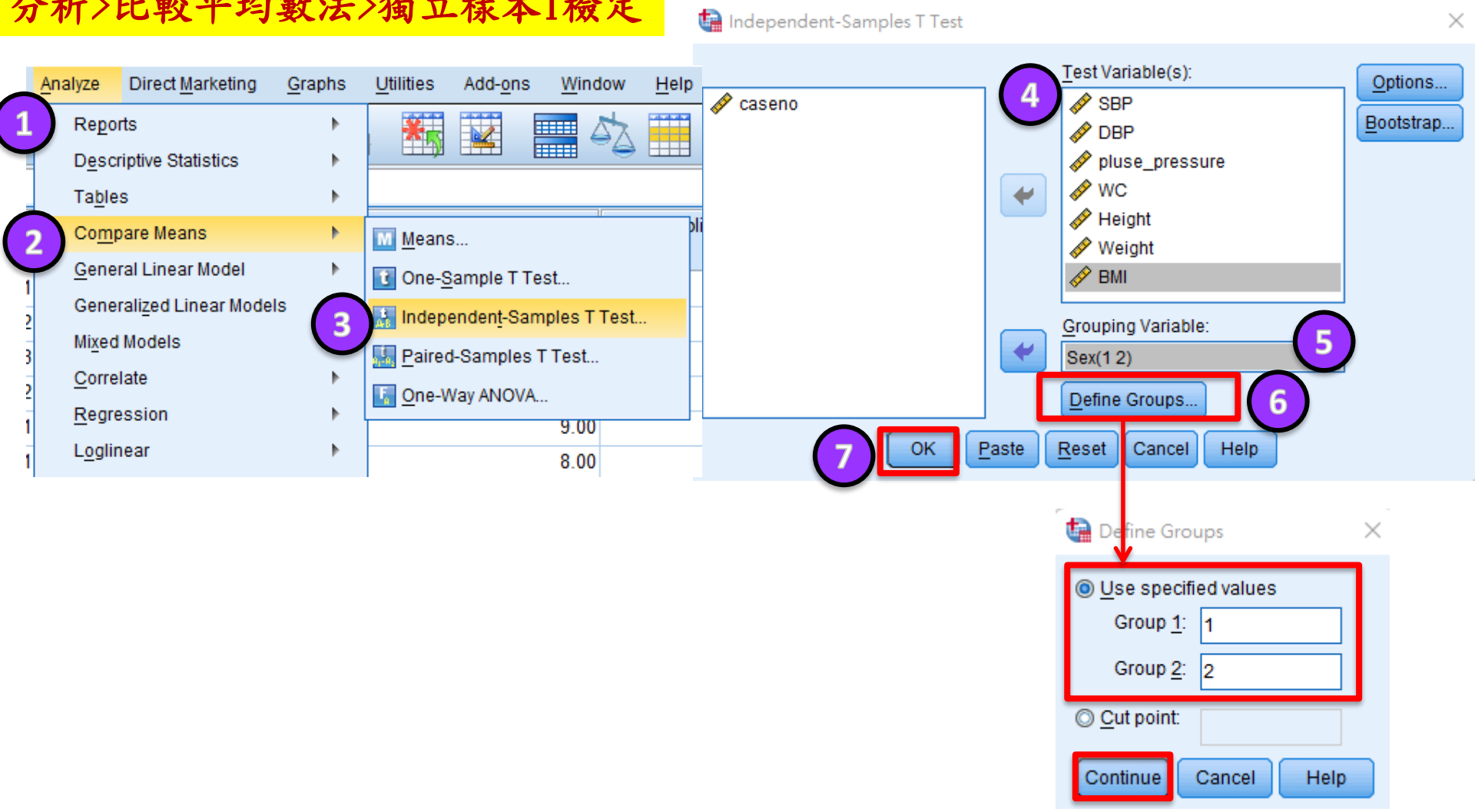
J Nutr Health Aging Volume 24, Number 6, 2020

Independent T-test SPSS dataset

caseno	Sex	SBP	DBP	pluse_pressure	WC	Height	Weight	BMI
1	1	150	83	67	95.50	165.60	76.70	27.97
2	1	135	68	67	99.06	157.00	69.30	28.11
3	1	131	77	54	93.00	163.00	72.50	27.29
4	1	144	93	51	97.00	169.30	76.90	26.83
5	1	149	78	71	91.95	163.50	70.00	26.19
6	1	140	70	70	91.44	174.00	76.00	25.10
7	1	140	71	69	93.00	170.50	77.30	26.59
8	1	110	91	19	92.00	177.40	78.00	24.78
9	1	133	80	53	99.06	158.10	75.40	30.13
10	1	135	91	44	96.00	173.50	79.00	26.24
11	1	130	78	52	91.44	166.00	82.00	29.76
12	1	140	90	50	102.00	156.00	66.00	27.12

Independent T-test SPSS analysis-2

分析>比較平均數法>獨立樣本T檢定



Independent T-test SPSS output

Group Statistics

	Sex	N	Mean	Std. Deviation	Std. Error Mean
SBP	Male	12331	134.59	18.950	.171
	Female	16833	134.90	19.438	.150
DBP	Male	12331	78.30	11.683	.105
	Female	16833	77.40	11.556	.089
pluse_pressure	Male	12331	56.29	14.332	.129
	Female	16833	57.49	14.784	.114
WC	Male	12331	86.9879	9.23906	.08320
	Female	16833	82.0870	9.54373	.07356

在舒張壓的部分，
男性和女性有統計差異
男生平均高於女生($p < 0.001$)

Levene檢定

1. 變異數相同($p>0.05$)
2. 變異數不相同($p<0.05$)

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
SBP	Equal variances assumed	6.621	.010	-1.346	29162		-.307	.228	-.754	.140
	Equal variances not assumed			-1.351	26938.705	.177	-.307	.227	-.752	.138
DBP	Equal variances assumed	6.533	.011	6.495	29162		.894	.138	.624	1.164
	Equal variances not assumed			6.484	26402.928	.000	.894	.138	.624	1.164
pluse_pressure	Equal variances assumed	18.439	.000	-6.940	29162		-1.201	.173	-1.540	-.862
	Equal variances not assumed			-6.974	27018.184	.000	-1.201	.172	-1.538	-.863

Mann-Whitney U test example

- Independent variable： Grade 0 and Grade1&2 (Two groups)
- Dependent variable：Global alignment angle、Shell angle and Lordotic angle..(Continuous)

Table 2
Anterior bone loss of the upper adjacent level by grade

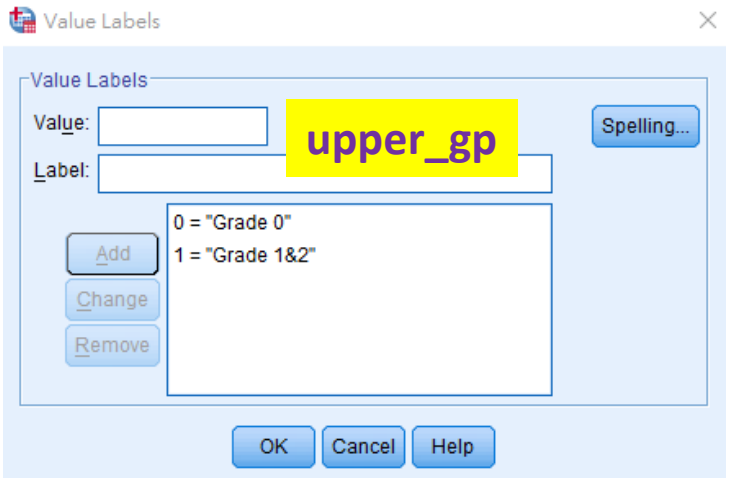
	Grade 0 (n=68)		Grades 1 & 2 (n=53)		p Value
Sex					.828
Female	32	(47.1%)	23	(43.4%)	
Male	36	(52.9%)	30	(56.6%)	
Age, years	50.5	(44.3, 56.0)	49.0	(43.5, 60.5)	.599
Operative level					.338
C3–4	6	(8.8%)	1	(1.9%)	
C4–5	20	(29.4%)	20	(37.7%)	
C5–6	38	(55.9%)	30	(56.6%)	
C6–7	4	(5.9%)	2	(3.8%)	
Hybrid					.688
No	37	(54.4%)	26	(49.1%)	
Yes	31	(45.6%)	27	(50.9%)	
Global alignment angle	15.0	(7.0, 22.8)	19.0	(9.0, 26.0)	.218
Shell angle	5.0	(1.3, 8.0)	7.0	(4.0, 10.5)	**.026***
Lordotic angle	4.9	(−0.0, 8.8)	4.6	(−0.7, 9.7)	.878
Mean degree of angle of the endplate with horizontal line	−16.2	(−20.3, −11.8)	−15.5	(−18.5, −11.2)	.349
Global ROM	40.0	(35.0, 55.0)	45.0	(38.0, 53.0)	.226
Index level ROM	9.0	(6.0, 13.0)	10.0	(5.0, 14.0)	.593

Chi-square test, Mann-Whitney *U* test, Median (interquartile range).
ROM, range of motion.
* $p < .05$.

The Spine Journal 20 (2020) 1211−1218

Mann-Whitney U test SPSS dataset

age	upper_gp	GA	SA	ROMG	ROMADR
57	.00	.0	8.0	2.0	2.0
58	.00	16.0	13.0	35.0	14.0
55	1.00	22.0	7.0	49.0	9.0
48	1.00	33.0	16.0	63.0	8.0
64	.00	37.0	10.0	39.0	3.0
49	1.00	9.0	4.0	63.0	14.0
56	.00	47.0	15.0	45.0	13.0
61	1.00	19.0	11.0	6.0	3.0
70	1.00	20.0	4.0	41.0	14.0
47	.00	15.0	7.0	35.0	6.0



Note

GA: Global alignment angle

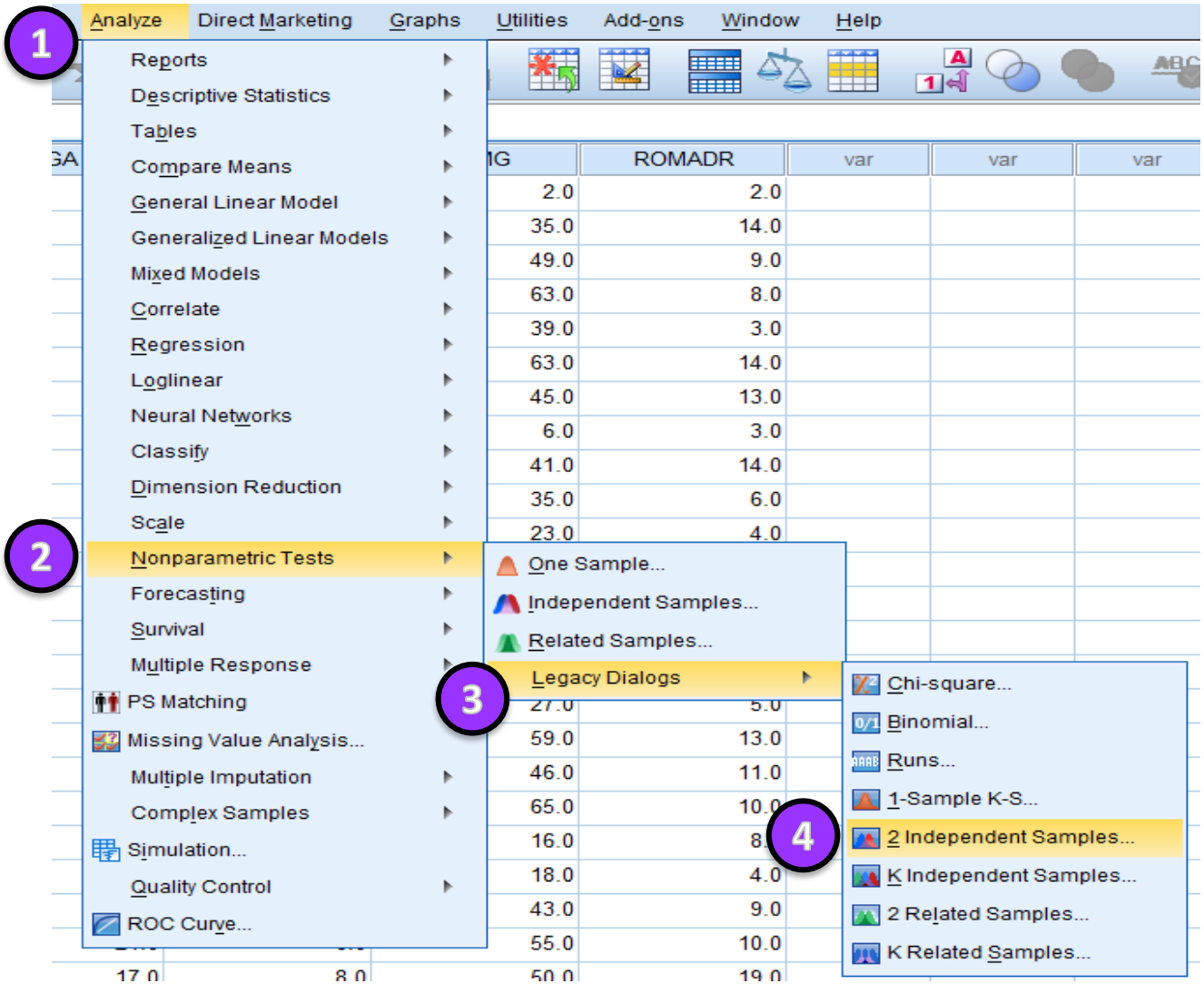
SA: Shell angle

ROMG: Global ROM

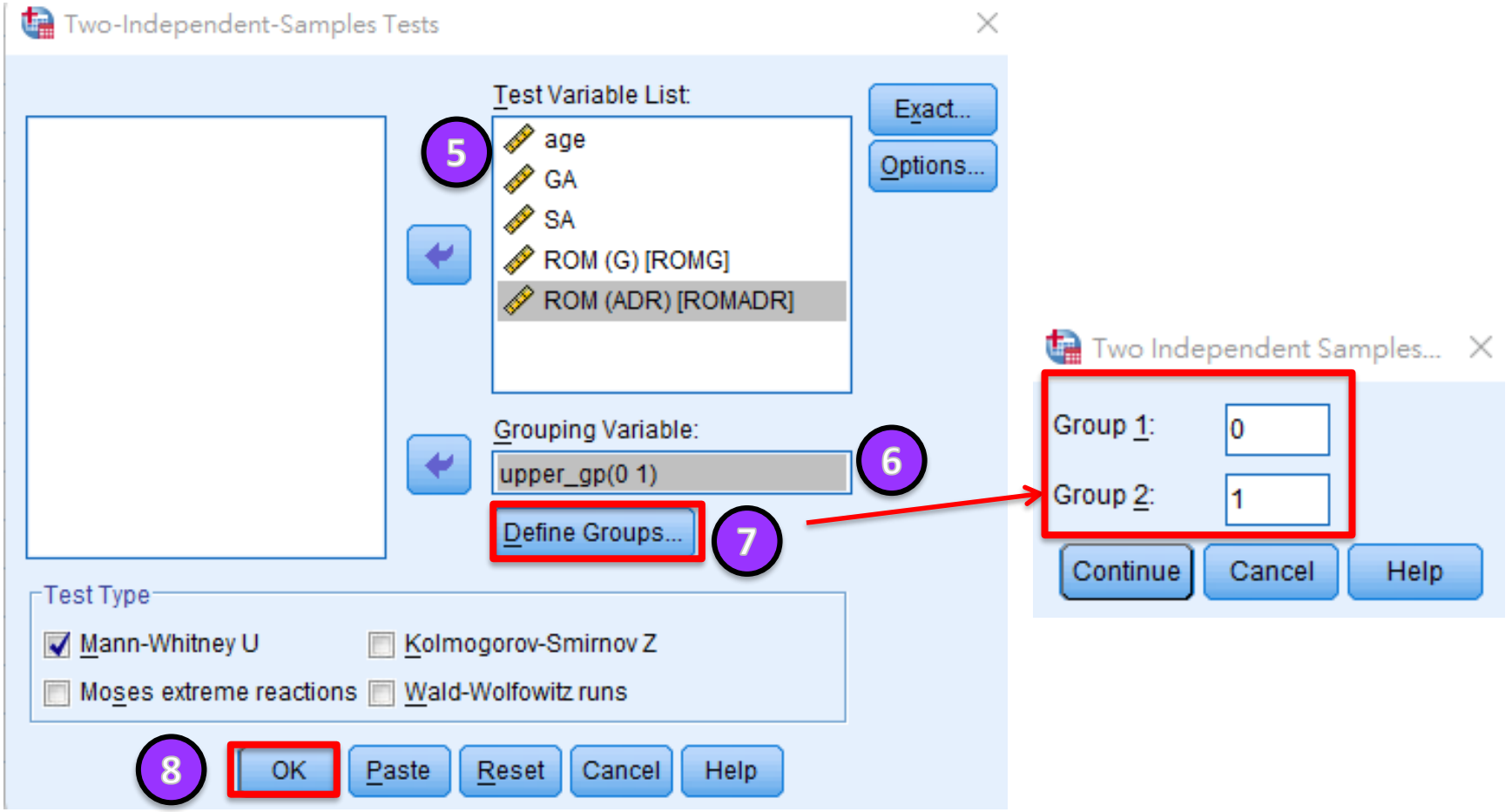
ROMADR: Index level ROM

Mann-Whitney U test SPSS analysis-1

分析>無母數檢定>歷史對話記錄>2個獨立樣本

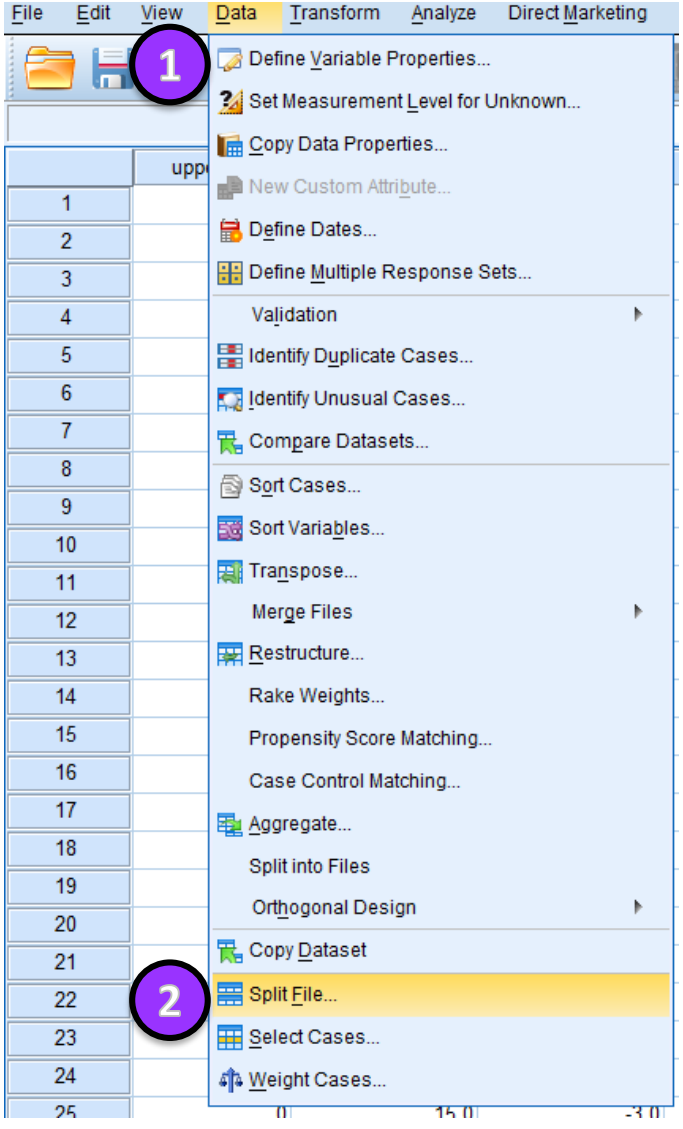


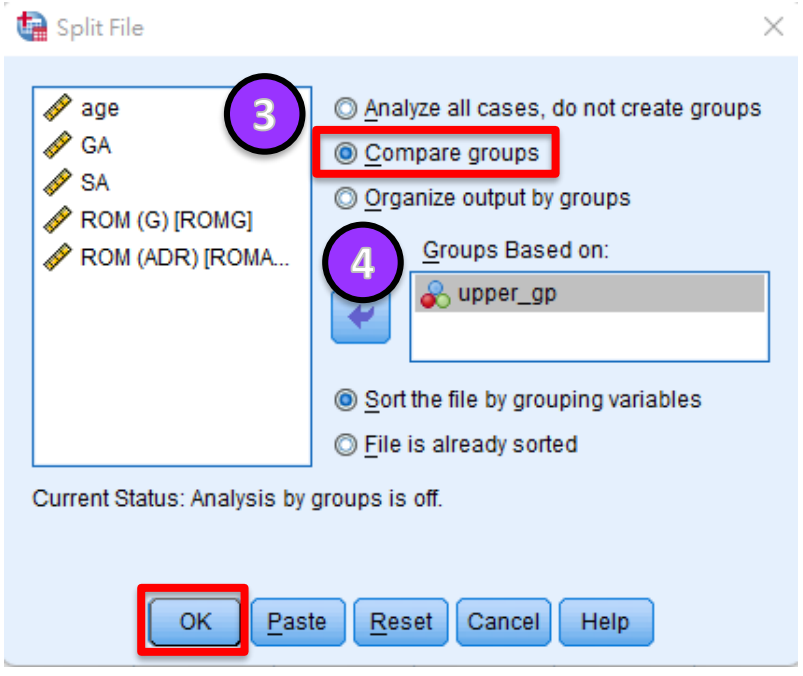
Mann-Whitney U test SPSS analysis-2



Mann-Whitney U test SPSS analysis-3

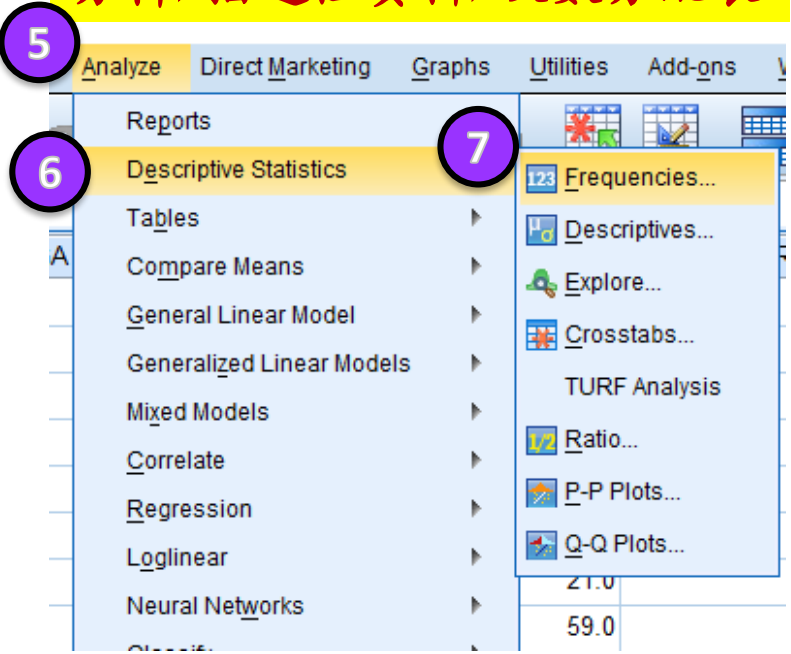
資料>分割檔案

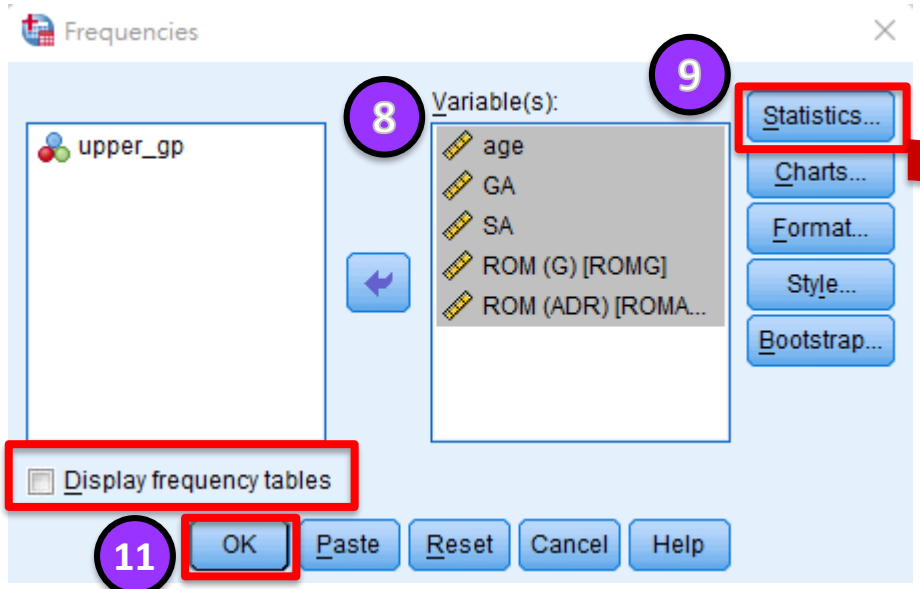


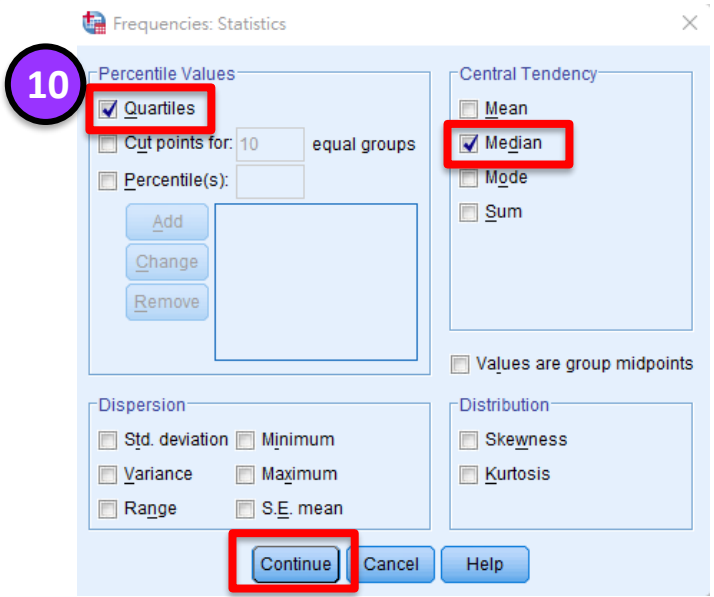


Mann-Whitney U test SPSS analysis-4

分析>描述性資料>次數分配表







Mann-Whitney U test SPSS output

Mann-Whitney Test

Ranks

	upper_gp	N	Mean Rank	Sum of Ranks
age	0	68	59.52	4047.50
	1	53	62.90	3333.50
	Total	121		
GA	0	68	57.54	3912.50
	1	53	65.44	3468.50
	Total	121		
SA	0	68	54.76	3724.00
	1	53	69.00	3657.00
	Total	121		
ROM (G)	0	67	57.08	3824.50
	1	53	64.82	3435.50
	Total	120		
ROM (ADR)	0	67	58.99	3952.50
	1	53	62.41	3307.50
	Total	120		

Test Statistics[a]

	age	GA	SA	ROM (G)	ROM (ADR)
Mann-Whitney U	1701.500	1566.500	1378.000	1546.500	1674.500
Wilcoxon W	4047.500	3912.500	3724.000	3824.500	3952.500
Z	-.525	-1.231	-2.220	-1.211	-.535
Asymp. Sig. (2-tailed)	.599	.218	.026	.226	.593

a. Grouping Variable: upper_gp

Frequencies

Statistics

upper_gp			age	GA	SA	ROM (G)	ROM (ADR)
0	N	Valid	68	68	68	67	67
		Missing	0	0	0	1	1
	Median		50.50	15.000	5.000	40.000	9.000
	Percentiles	25	44.25	7.000	1.250	35.000	6.000
		50	50.50	15.000	5.000	40.000	9.000
		75	56.00	22.750	8.000	55.000	13.000
1	N	Valid	53	53	53	53	53
		Missing	0	0	0	0	0
	Median		49.00	19.000	7.000	45.000	10.000
	Percentiles	25	43.50	9.000	4.000	38.000	5.000
		50	49.00	19.000	7.000	45.000	10.000
		75	60.50	26.000	10.500	53.000	14.000

在SA的部分，
Grade0和Grade1&2有統計差異
Grade1&2中位數高於Grade0 (p=0.026)

Two group-相依樣本

Paired T-test

- 檢定兩組相依樣本的平均值是否有差異
- 適用於配對樣本，資料需符合常態分佈

Wilcoxon signed-rank

- 檢定兩組相依樣本的中位數是否有差異
- 適用於配對樣本，資料呈非常態分佈

https://reurl.cc/MX0KM4

Paired T-test example

- Independent variable：2014 and 2016 (Paired)
- Dependent variable：Age、BMI、Height and Weight….(Continuous)

TABLE 1 | Demographic data of study participants in 2014 and 2016.

	2014 (n = 4,537)		2016 (n = 4,537)		p-value
	n	%	n	%	
Age	71.75	±5.93	73.75	±5.93	–
Gender					1.000
Male	2,207	(48.6%)	2,207	(48.6%)	
Female	2,330	(51.4%)	2,330	(51.4%)	
Smoking	309	(6.8%)	297	(6.5%)	0.119
Drinking	547	(12.1%)	581	(12.8%)	0.862
Exercise	3,237	(71.3%)	3,462	(76.3%)	0.930
BMI	24.49	±3.47	24.41	±3.42	**0.004****
Height (cm)	157.67	±8.15	157.59	±8.12	0.063
Weight (kg)	60.99	±10.38	60.78	±10.47	**<0.001****
Waist (cm)	83.20	±9.72	84.59	±9.66	**<0.001****
SBP (mmHg)	133.91	±18.19	134.63	±18.52	**0.007****
DBP (mmHg)	78.14	±10.91	77.21	±11.26	**<0.001****
Pulse pressure (mmHg)	55.77	±13.82	57.42	±13.74	**<0.001****
Fasting plasma glucose (mg/dl)	104.02	±21.92	104.89	±25.17	**0.009****
Triglycerides (mg/dl)	117.03	±66.71	114.85	±67.83	**0.024***
HDL cholesterol (mg/dl)	55.61	±15.66	55.60	±15.78	0.922

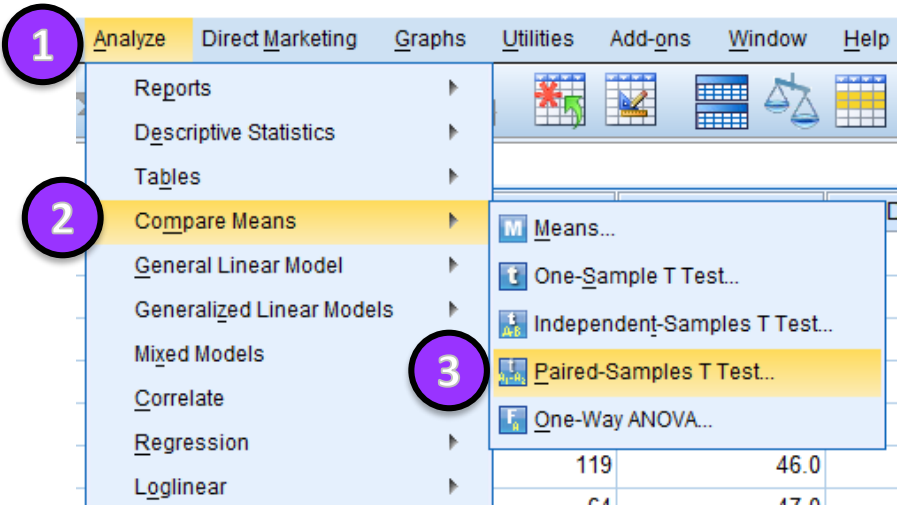
Frontiers in Medicine (2021), 8

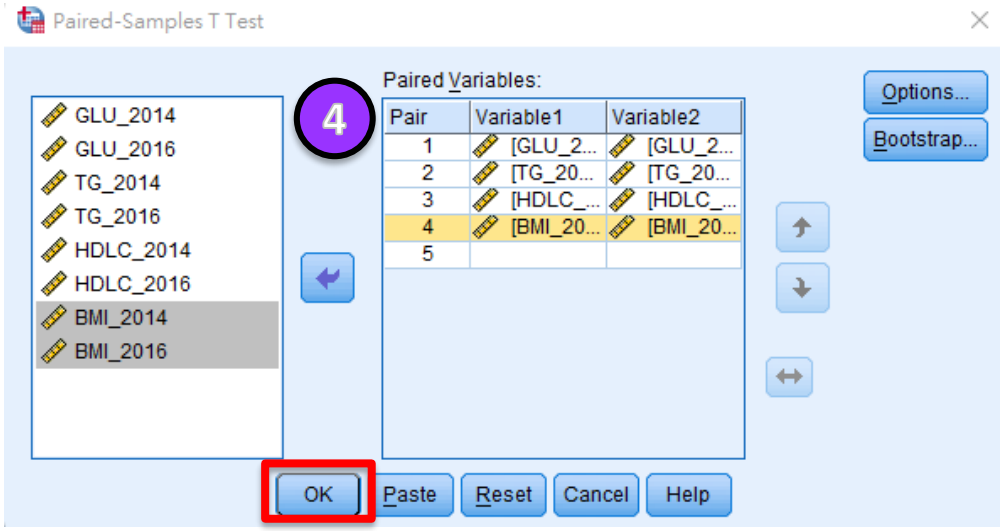
Paired T-test SPSS dataset

caseno	GLU_2014	GLU_2016	TG_2014	TG_2016	HDLC_2014	HDLC_2016	BMI_2014	BMI_2016
1	91	91	245	180	34.0	42.0	27.68	27.27
2	103	224	89	104	45.0	35.0	19.15	20.16
3	92	96	96	56	54.0	47.0	20.94	23.57
4	97	96	123	92	57.0	57.0	25.54	25.57
5	88	307	125	106	42.0	87.0	18.97	17.10
6	94	94	101	119	46.0	47.0	21.50	21.79
7	92	91	49	64	47.0	50.0	25.67	26.58
8	151	89	83	69	39.0	47.0	24.61	26.37
9	97	97	120	59	42.0	44.0	23.95	24.31
10	149	156	142	128	50.0	50.0	25.54	23.84
11	113	124	337	104	58.0	80.0	23.28	23.74
12	99	92	114	76	67.0	60.0	20.20	20.57

Paired T-test SPSS analysis

分析>比較平均數法>成對樣本T檢定





Paired T-test SPSS output

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	GLU_2014	104.02	4537	21.923	.325
	GLU_2016	104.89	4537	25.166	.374
Pair 2	TG_2014	117.03	4537	66.712	.990
	TG_2016	114.85	4537	67.833	1.007
Pair 3	HDLC_2014	55.615	4537	15.6628	.2325
	HDLC_2016	55.598	4537	15.7802	.2343
Pair 4	BMI_2014	24.4877	4537	3.46738	.05148
	BMI_2016	24.4141	4537	3.41873	.05076

在Glucose的部分，
2014和2016有統計差異
2016平均高於2014 (p=0.009)

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	GLU_2014 - GLU_2016	-.869	22.503	.334	-1.524	-.214	-2.600	4536	.009
Pair 2	TG_2014 - TG_2016	2.186	65.013	.965	.294	4.078	2.265	4536	.024
Pair 3	HDLC_2014 - HDLC_2016	.0164	11.3191	.1680	-.3131	.3458	.098	4536	.922
Pair 4	BMI_2014 - BMI_2016	.07361	1.73773	.02580	.02303	.12418	2.853	4536	.004

Wilcoxon signed-rank test example

- Independent variable：Pre-op and Post-op (Paired)
- Dependent variable：Local、Pelvic and Spinal parameters….(Continuous)

Table 2 Changes in pre- and postoperative radiographic parameters pre-operative and postoperative data

	Pre-operative ($n = 11$)		Postoperative ($n = 11$)		p value
Local parameters					
Slip percentage	60.0	(53.0, 62.0)	30.0	(23.0, 36.0)	0.003**
Dubousset's lumbosacral angle	84.1	(75.6, 92.3)	97.9	(92.5, 111.4)	0.003**
Pelvic parameters					
Pelvic tilt	24.2	(22.2, 30.5)	25.4	(15.8, 30.4)	0.131
Pelvic incidence	62.1	(53.1, 80.8)	64.9	(52.1, 81.4)	0.059
Sacral slope	32.3	(30.4, 49.1)	41.9	(35.9, 52.2)	0.091
Spinal parameters					
LL	−49.4	(−70.3, −34.7)	−57.7	(−70.0, −47.1)	0.013*
PI-LL mismatch	16.0	(10.0, 26.3)	9.9	(0.0, 19.0)	0.021*
SVA (mm)	36.9	(18.3, 59.8)	23.6	(0.1, 54.1)	0.213

Wilcoxon signed rank, median (IQR). *$P < 0.05$, **$P < 0.01$

Abbreviations: *LL* Lumbar Lordosis; *PI* Pelvic Incidence.; *SVA* sagittal vertical axis

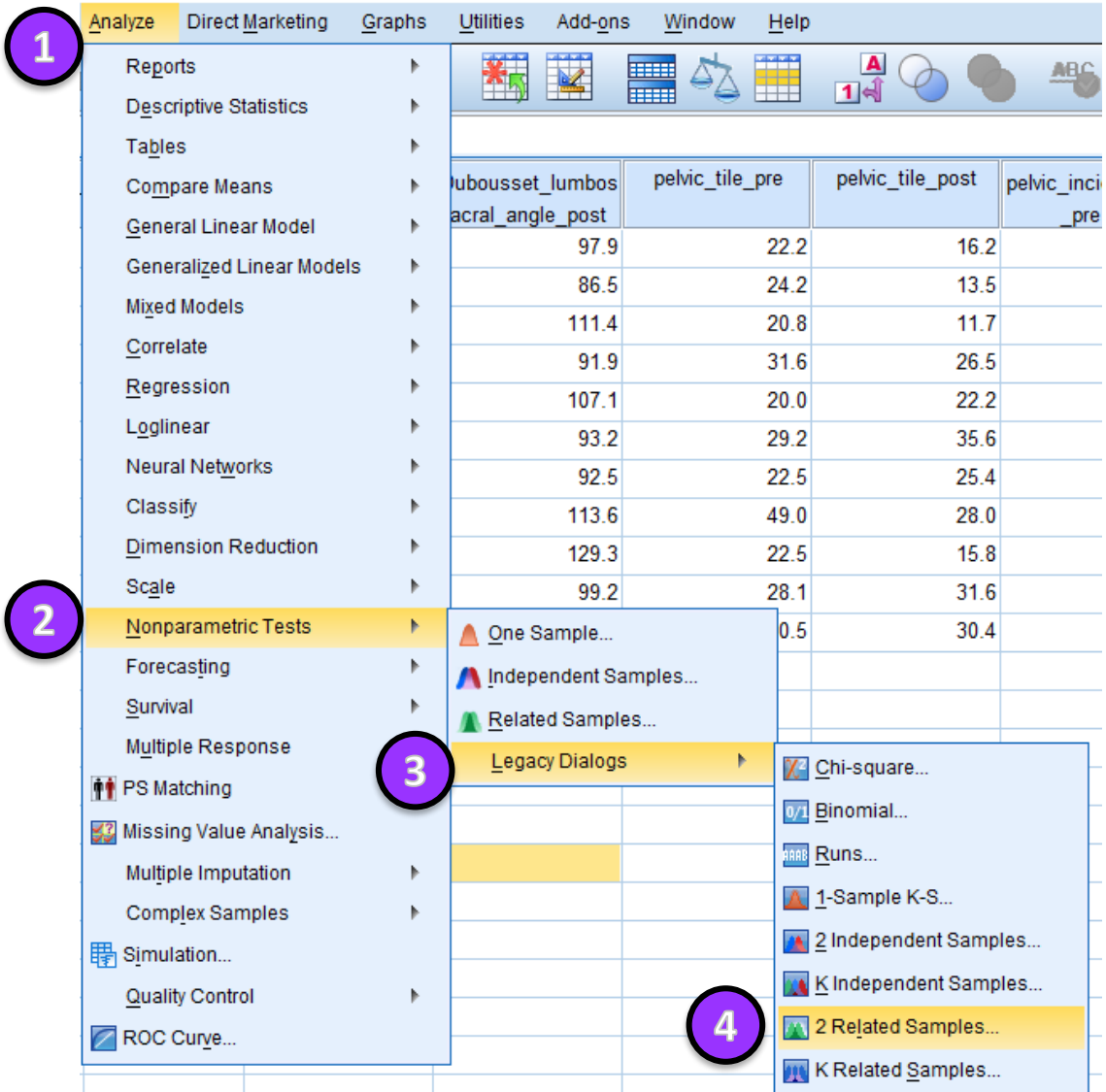
BMC Musculoskeletal Disorders (2021) 22:559

Wilcoxon signed-rank SPSS dataset

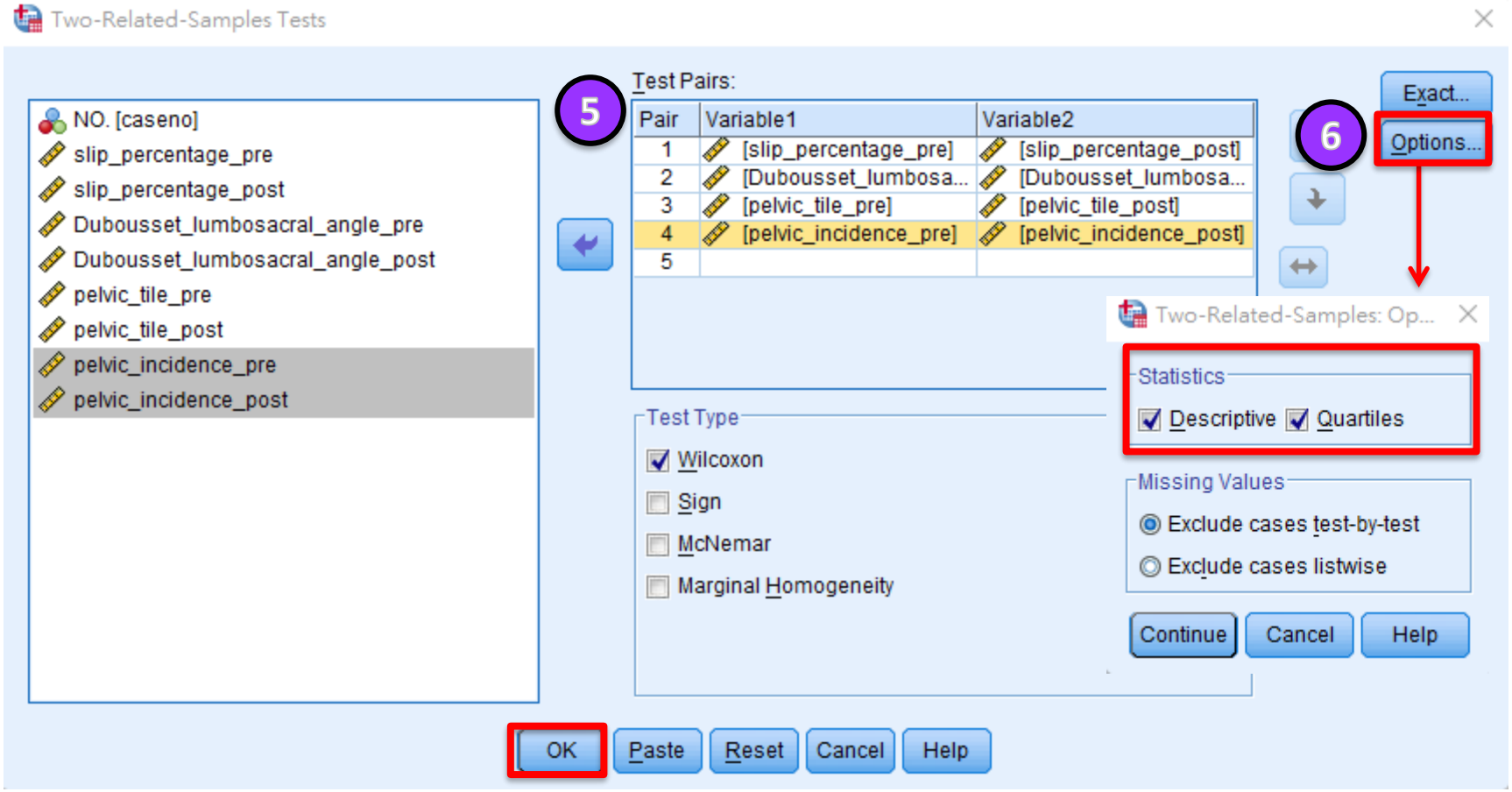
caseno	slip_percentage_pre	slip_percentage_post	Dubousset_lumbosacral_angle_pre	Dubousset_lumbosacral_angle_post	pelvic_tile_pre	pelvic_tile_post	pelvic_incidence_pre	pelvic_incidence_post
1	60.0	44.0	78.7	97.9	22.2	16.2	53.1	52.1
2	76.0	49.0	67.8	86.5	24.2	13.5	65.4	65.7
3	60.0	16.0	92.3	111.4	20.8	11.7	51.2	50.3
4	59.0	30.0	77.8	91.9	31.6	26.5	62.1	64.9
5	52.0	36.0	100.3	107.1	20.0	22.2	49.9	51.0
6	62.0	33.0	68.7	93.2	29.2	35.6	55.5	57.3
7	53.0	23.0	75.6	92.5	22.5	25.4	71.6	71.6
8	53.0	26.0	84.1	113.6	49.0	28.0	81.3	82.0
9	66.0	18.0	99.7	129.3	22.5	15.8	56.5	57.7
10	60.0	36.0	90.2	99.2	28.1	31.6	85.0	86.8
11	53.0	30.0	87.5	94.8	30.5	30.4	80.8	81.4

Wilcoxon signed-rank SPSS analysis-1

分析>無母數檢定>歷史對話記錄>2個相關樣本



Wilcoxon signed-rank SPSS analysis-2



Wilcoxon signed-rank SPSS output

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum	Percentiles		
						25th	50th (Median)	75th
slip_percentage_pre	11	59.455	7.1044	52.0	76.0	53.000	60.000	62.000
Dubousset_lumbosacral_angle_pre	11	83.882	11.2483	67.8	100.3	75.600	84.100	92.300
pelvic_tile_pre	11	27.327	8.2529	20.0	49.0	22.200	24.200	30.500
pelvic_incidence_pre	11	64.764	12.9977	49.9	85.0	53.100	62.100	80.800
slip_percentage_post	11	31.000	10.1587	16.0	49.0	23.000	30.000	36.000
Dubousset_lumbosacral_angle_post	11	101.582	12.5648	86.5	129.3	92.500	97.900	111.400
pelvic_tile_post	11	23.355	8.0360	11.7	35.6	15.800	25.400	30.400
pelvic_incidence_post	11	65.527	13.2864	50.3	86.8	52.100	64.900	81.400

Test Statistics[a]

	slip_percentage_post - slip_percentage_pre	Dubousset_lumbosacral_angle_post - Dubousset_lumbosacral_angle_pre	pelvic_tile_post - pelvic_tile_pre	pelvic_incidence_post - pelvic_incidence_pre
Z	-2.938[b]	-2.934[c]	-1.511[b]	-1.887[c]
Asymp. Sig. (2-tailed)	.003	.003	.131	.059

a. Wilcoxon Signed Ranks Test

b. Based on positive ranks.

c. Based on negative ranks.

在Slip percentage的部分，
Pre-op和Post-op有統計差異
Pre-op平均高於Post-op (p=0.003)

Three group-獨立樣本

One-way ANOVA

- 檢定3組以上的平均數是否相等
- 適用於常態分佈資料

Kruskal-Wallis test

- 檢定3組以上的中位數是否相等
- 適用於非常態分佈資料

One-way ANOVA example

- Independent variable： CKD stage (Three groups+)
- Dependent variable：Lab data, pH、HCO3、PT and INR…(Continuous)

Table 1. Baseline characteristics of all participants divided according to their stages of CKD.

	CKD Stage												Total (n = 12,271)		p-Value
	I		II		IIIA		IIIB		IV		V				
Laboratory data of blood															
Hb (n = 12,242)	12.30	±2.45	12.36	±2.49	11.98	±2.58	11.56	±2.67	11.05	±2.75	10.13	±2.72	12.08	±2.57	<0.001
Albumin (n = 6940)	3.42	±0.74	3.44	±0.73	3.31	±0.72	3.18	±0.72	3.00	±0.73	3.07	±0.67	3.35	±0.74	<0.001
Calcium (n = 9455)	7.81	±1.71	8.00	±1.70	8.06	±1.62	7.93	±1.78	7.92	±1.67	7.80	±1.86	7.91	±1.71	<0.001
Uric acid (n = 730)	4.98	±2.09	6.42	±2.60	7.26	±2.11	8.34	±2.94	8.73	±3.07	8.38	±2.61	6.67	±2.81	<0.001
Sodium (n = 12,153)	137.36	±5.37	137.91	±5.37	137.42	±6.19	137.56	±6.79	138.07	±7.56	137.20	±6.72	137.59	±5.80	<0.001
Potassium (n = 12,146)	3.98	±0.64	4.03	±0.65	4.10	±0.75	4.23	±0.87	4.34	±0.90	4.46	±1.02	4.07	±0.72	<0.001

Table 1. *Cont.*

	CKD Stage												Total (n = 12,271)		p-Value
	I		II		IIIA		IIIB		IV		V				
pH (n = 9348)	6.89	±0.80	6.82	±0.86	6.82	±0.89	6.92	±0.85	7.01	±0.81	7.27	±0.56	6.89	±0.83	<0.001
HCO_3^- (n = 5768)	25.14	±4.44	24.55	±4.82	23.68	±5.13	22.55	±5.54	20.31	±5.77	20.51	±5.89	23.84	±5.22	<0.001
PT (n = 9863)	11.49	±3.21	11.79	±5.41	12.00	±4.70	12.91	±7.26	13.58	±7.50	12.80	±6.77	11.93	±5.04	<0.001
INR (n = 9857)	1.09	±0.24	1.12	±0.49	1.15	±0.46	1.23	±0.67	1.30	±0.74	1.20	±0.49	1.14	±0.45	<0.001
Medications															
NSAID	2788	(57.3%)	1858	(49.8%)	608	(40.7%)	427	(37.8%)	204	(31.6%)	91	(22.7%)	5976	(48.7%)	<0.001
ASPIRIN	561	(11.5%)	749	(20.1%)	391	(26.2%)	337	(29.8%)	201	(31.2%)	130	(32.4%)	2369	(19.3%)	<0.001
COX2i	541	(11.1%)	460	(12.3%)	231	(15.5%)	154	(13.6%)	74	(11.5%)	38	(9.5%)	1498	(12.2%)	<0.001
Aminoglycoside	2285	(46.9%)	1651	(44.3%)	590	(39.5%)	407	(36.0%)	218	(33.8%)	114	(28.4%)	5265	(42.9%)	<0.001
Loop diuretics	2230	(45.8%)	1921	(51.5%)	946	(63.3%)	816	(72.1%)	497	(77.1%)	251	(62.6%)	6661	(54.3%)	<0.001

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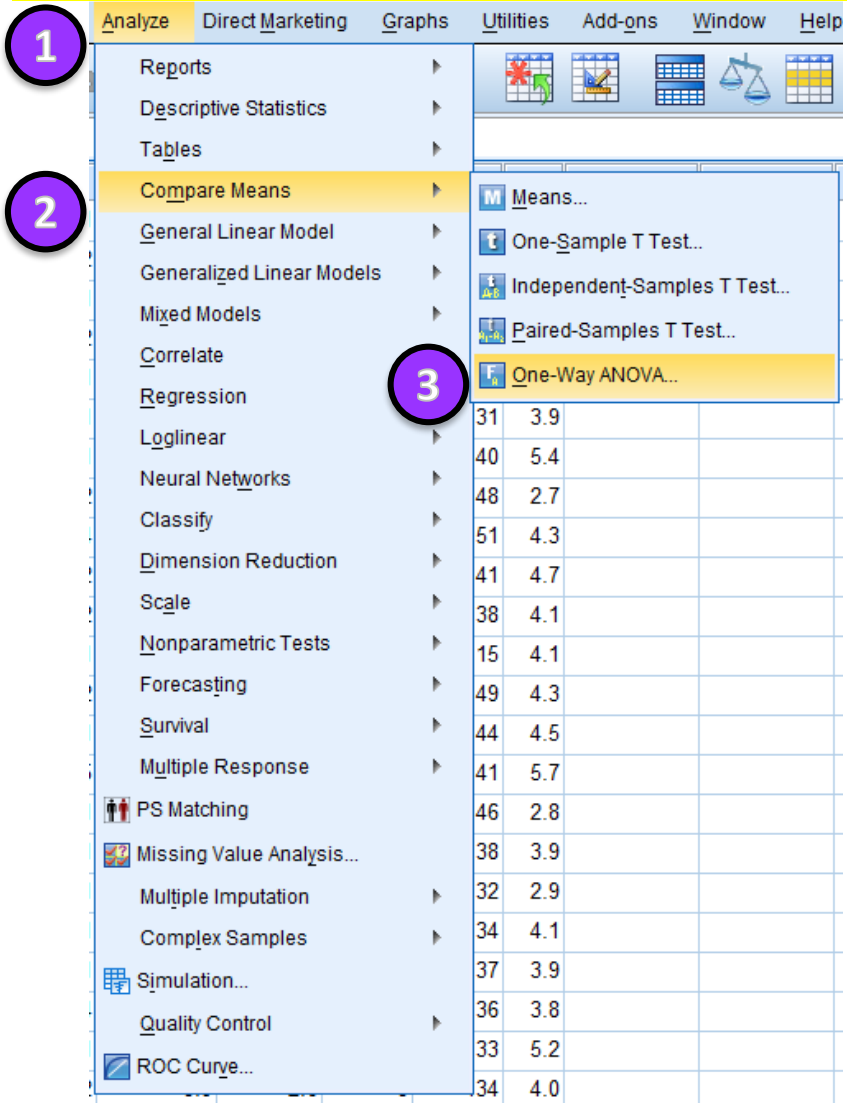
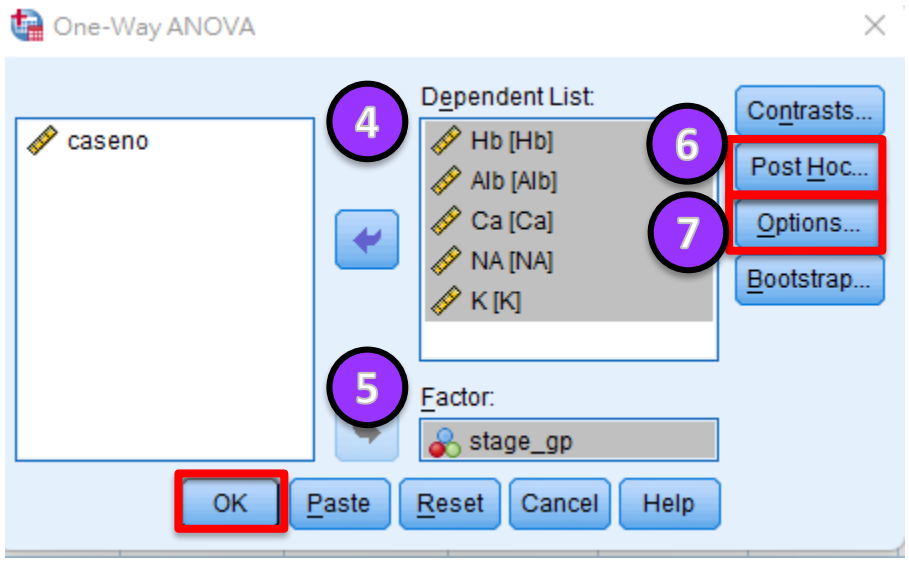
ANOVA SPSS dataset

caseno	stage_gp	Hb	Alb	Ca	NA	K
2	1	9.6	1.8	4	135	4.3
3	2	8.3	.	4	131	5.6
4	1	7.5	2.2	8	138	4.1
5	2	10.0	2.6	8	136	3.6
6	1	9.1	3.1	6	140	4.7
8	1	14.5	2.6	8	131	3.9
9	1	10.8	2.7	8	140	5.4
12	2	14.5	3.8	8	148	2.7
13	4	10.9	2.1	9	151	4.3
14	2	10.6	2.7	4	141	4.7
15	2	9.6	3.1	8	138	4.1
16	1	15.6	4.1	8	115	4.1

ANOVA SPSS analysis-1

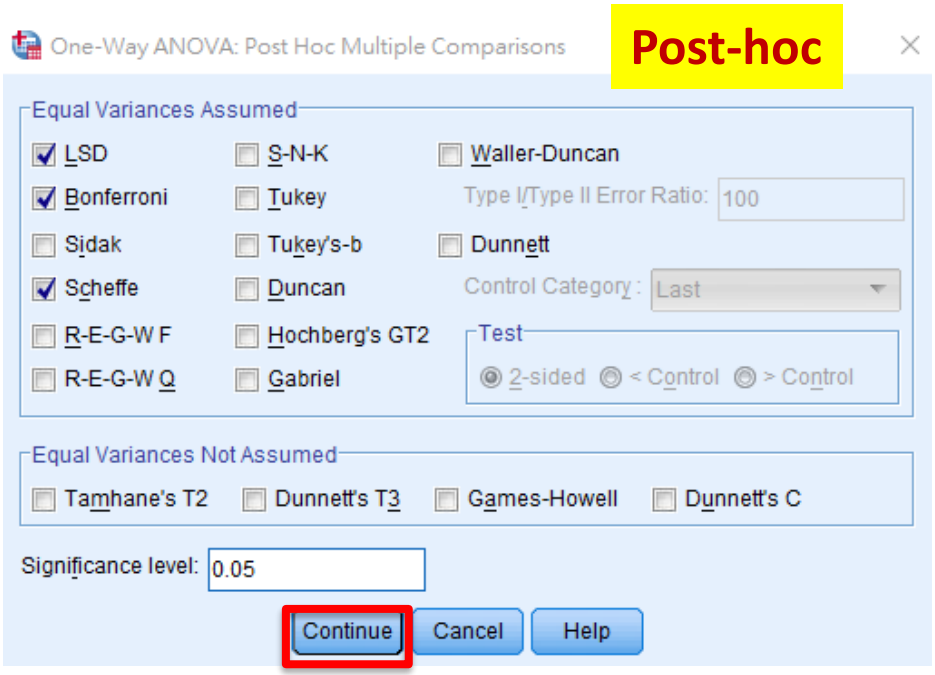
分析>比較平均數法>單因子變異數分析



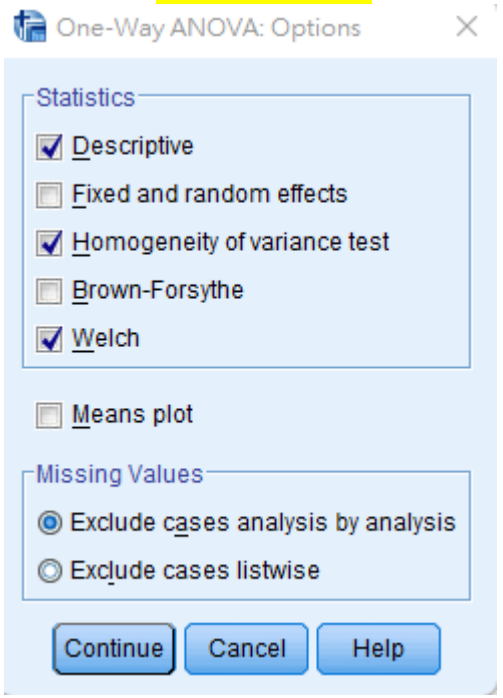


ANOVA SPSS analysis-2

Post-hoc



Options



ANOVA SPSS output-1

Descriptives

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
						Lower Bound	Upper Bound		
Hb	>=90	4860	12.301	2.4542	.0352	12.232	12.370	4.3	20.1
	60-90	3722	12.365	2.4885	.0408	12.285	12.445	3.1	19.0
	45-60	1489	11.984	2.5768	.0668	11.853	12.115	4.2	19.3
	30-45	1128	11.562	2.6699	.0795	11.406	11.718	4.0	19.0
	15-30	644	11.045	2.7465	.1082	10.833	11.258	4.7	19.1
	<15	399	10.133	2.7236	.1363	9.865	10.401	3.4	17.5
	Total	12242	12.077	2.5737	.0233	12.031	12.122	3.1	20.1
Alb	>=90	2674	3.418	.7383	.0143	3.390	3.446	.2	5.9
	60-90	2028	3.444	.7257	.0161	3.413	3.476	.8	5.4
	45-60	855	3.306	.7158	.0245	3.258	3.354	.4	5.4
	30-45	680	3.179	.7195	.0276	3.124	3.233	1.1	5.8
	15-30	427	2.999	.7309	.0354	2.929	3.068	.5	6.7
	<15	276	3.071	.6682	.0402	2.992	3.150	1.0	5.2
	Total	6940	3.349	.7391	.0089	3.331	3.366	.2	6.7

在Alb的部分，
不同CKD stage程度有統計差異
Stage II平均高於其他 ($p<0.001$)

Test of Homogeneity of Variances

	Levene Statistic	df1	df2	Sig.
Hb	15.688	5	12236	.000
Alb	2.103	5	6934	.062

ANOVA

Alb

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	126.191	5	25.238	47.763	.000
Within Groups	3663.970	6934	.528		
Total	3790.161	6939			

Alb, $p>0.05$ 三組變異數無差異(同質性)
Hb, 違反同質性假設

Robust Tests of Equality of Means

Hb

	Statistic[a]	df1	df2	Sig.
Welch	85.179	5	2215.976	.000

a. Asymptotically F distributed.

Hb用Welch結果, 取代ANOVA
$p<0.001$

ANOVA SPSS output-2

Multiple Comparisons

Dependent Variable: Alb

Bonferroni

(I) stage_gp	(J) stage_gp	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
>=90	60-90	-.0260	.0214	1.000	-.089	.037
	45-60	.1121*	.0286	.001	.028	.196
	30-45	.2396*	.0312	.000	.148	.331
	15-30	.4193*	.0379	.000	.308	.531
	<15	.3472*	.0460	.000	.212	.482
60-90	>=90	.0260	.0214	1.000	-.037	.089
	45-60	.1381*	.0296	.000	.051	.225
	30-45	.2657*	.0322	.000	.171	.360
	15-30	.4454*	.0387	.000	.332	.559
	<15	.3732*	.0466	.000	.236	.510
45-60	>=90	-.1121*	.0286	.001	-.196	-.028
	60-90	-.1381*	.0296	.000	-.225	-.051
	30-45	.1276*	.0374	.010	.018	.237
	15-30	.3073*	.0431	.000	.181	.434
	<15	.2351*	.0503	.000	.087	.383
30-45	>=90	-.2396*	.0312	.000	-.331	-.148
	60-90	-.2657*	.0322	.000	-.360	-.171
	45-60	-.1276*	.0374	.010	-.237	-.018
	15-30	.1797*	.0449	.001	.048	.311
	<15	.1075	.0519	.574	-.045	.260
15-30	>=90	-.4193*	.0379	.000	-.531	-.308
	60-90	-.4454*	.0387	.000	-.559	-.332
	45-60	-.3073*	.0431	.000	-.434	-.181
	30-45	-.1797*	.0449	.001	-.311	-.048
	<15	-.0722	.0561	1.000	-.237	.093
<15	>=90	-.3472*	.0460	.000	-.482	-.212
	60-90	-.3732*	.0466	.000	-.510	-.236
	45-60	-.2351*	.0503	.000	-.383	-.087
	30-45	-.1075	.0519	.574	-.260	.045
	15-30	.0722	.0561	1.000	-.093	.237

*. The mean difference is significant at the 0.05 level.

在Alb的事後檢定，p<0.05
Stage I vs Stage IIIA;
Stage I vs Stage IIIB;
Stage I vs Stage IV;
Stage I vs Stage V;
Stage II vs Stage IIIA;
Stage II vs Stage IIIB;
Stage II vs Stage IV;
Stage II vs Stage V;
……..

Kruskal-Wallis test example

- Independent variable： Typical, LP, HS and MA (Four groups)
- Dependent variable：Age, Education years and MMSE…(Continuous)

Table 1 Clinical and imaging characteristics of the cohort, $N = 137$

Characteristic	Typical ($N=33$)		LP ($N=26$)		HS ($N=40$)		MA ($N=38$)		*P* value
Sex, female, *N* (%)	20	(60.6%)	12	(46.2%)	25	(62.5%)	31	(81.6%)	0.030*
Age, years	81.0	(74.5–83.5)	76.5	(65.8–84.3)	79.5	(76.0–84.0)	77.0	(70.8–79.0)	0.010*
Education, years	6.0	(6–10.5)	6.0	(6.0–12.0)	6.0	(6.0–9.0)	6.0	(0.0–12.0)	0.659
Smoking, *N* (%)	4	(12.1%)	1	(3.8%)	2	(5.0%)	3	(7.9%)	0.588
Vascular risk factors									
Hypertension, *N* (%)	18	(54.5%)	12	(46.2%)	26	(65.0%)	23	(60.5%)	0.466
Diabetes mellitus, *N* (%)	12	(36.4%)	7	(26.9%)	21	(52.5%)	10	(26.3%)	0.067
Hyperlipidemia, *N* (%)	7	(21.2%)	9	(34.6%)	21	(52.5%)	14	(36.8%)	0.053
Peripheral or cardiac vasculopathy[a]	0	(0.0%)	6	(23.1%)	7	(17.5%)	6	(15.8%)	0.052
Atrial fibrillation, *N* (%)	4	(12.1%)	1	(3.8%)	2	(5.0%)	3	(7.9%)	0.588
Number of vascular risk factors	1.0	(0.0–2.0)	0.5	(0.0–3.0)	2.0	(1.0–3.0)	1.0	(0.0–3.0)	0.091
Use of antiplatelet, *N* (%)	5	(15.2%)	5	(19.2%)	13	(32.5%)	13	(34.2%)	0.186
Use of anticoagulant, *N* (%)	3	(9.1%)	1	(3.8%)	2	(5.0%)	2	(5.3%)	0.826
MMSE	18.0	(12.5–21.5)	16.0	(12.5–21.0)	20.0	(16.0–22.8)	20.0	(14.0–22.5)	0.117
MoCA	12.0	(9.5–14.0)	9.0	(6.5–13.5)	14.0	(10.0–18.0)	14.5	(8.3–18.8)	0.045*
CDR	1.0	(0.5–1.0)	1.0	(0.8–1.0)	1.0	(0.5–1.0)	0.5	(0.5–1.0)	0.021*
CDR—sum of boxes	6.0	(3.6–8.0)	6.0	(4.3–7.5)	4.0	(3.0–5.5)	4.5	(3.0–5.4)	0.006**

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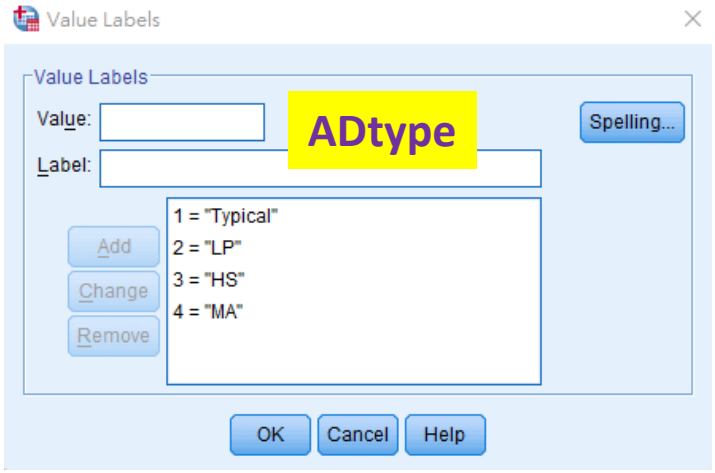
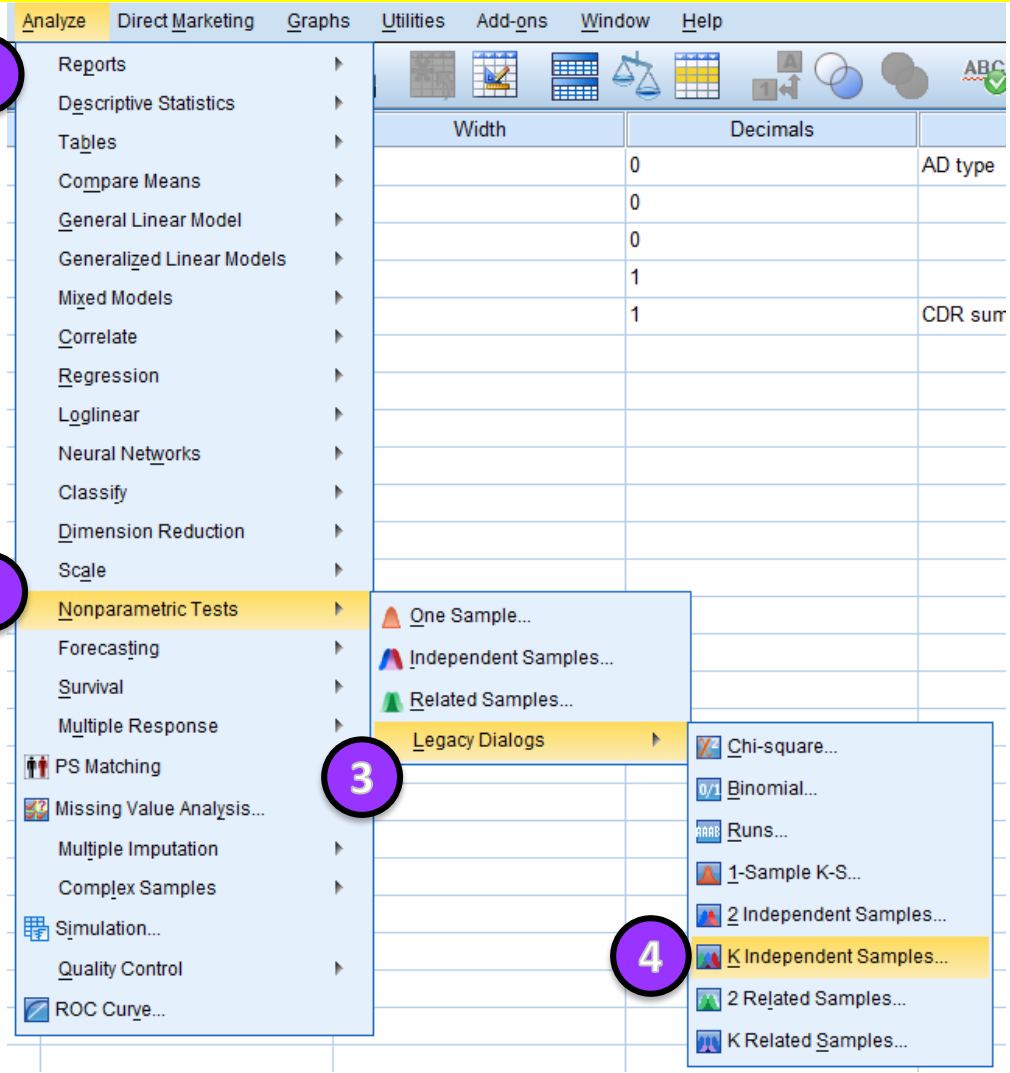
Kruskal-Wallis test SPSS dataset

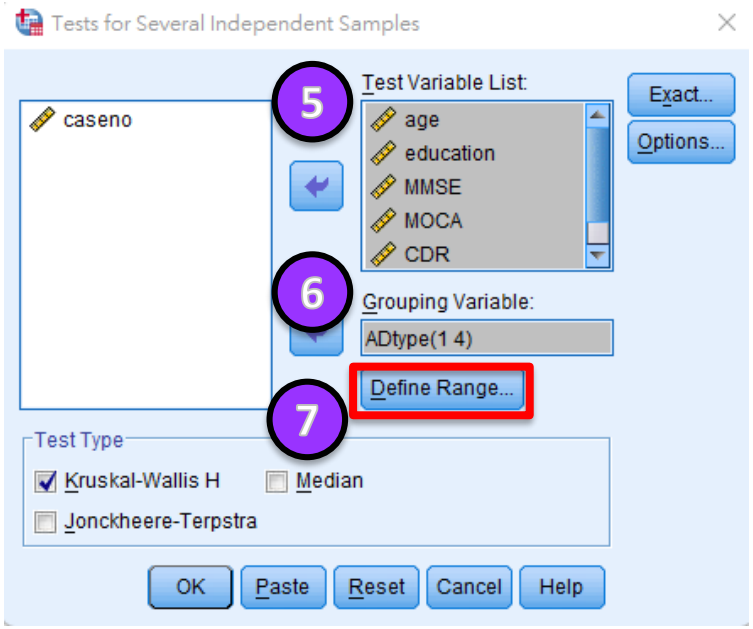
caseno	age	education	ADtype	MMSE	MOCA	CDR	CDRsumbox
1	90	0	2	.	.	2.0	10.0
2	89	6	2	16	11	.	.
3	76	0	4	15	8	.	.
4	77	0	4	15	.	2.0	10.0
5	72	16	4	26	26	.5	2.0
6	77	6	2	11	.	2.0	10.0
7	70	6	4	20	14	.5	4.5
8	80	6	4	22	17	.5	3.5
9	78	0	4	10	5	1.0	5.0
10	83	6	3	11	9	.5	4.0
11	79	6	1	17	5	.5	2.5
12	79	0	4	20	9	1.0	4.5

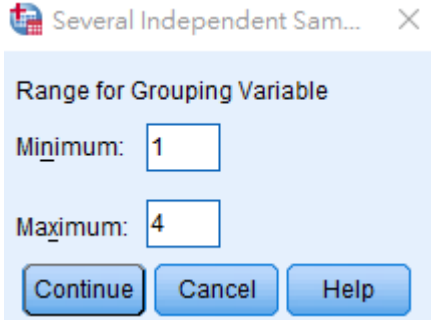


Kruskal-Wallis test SPSS analysis-1

分析>無母數檢定>歷史對話記錄>K個獨立樣本

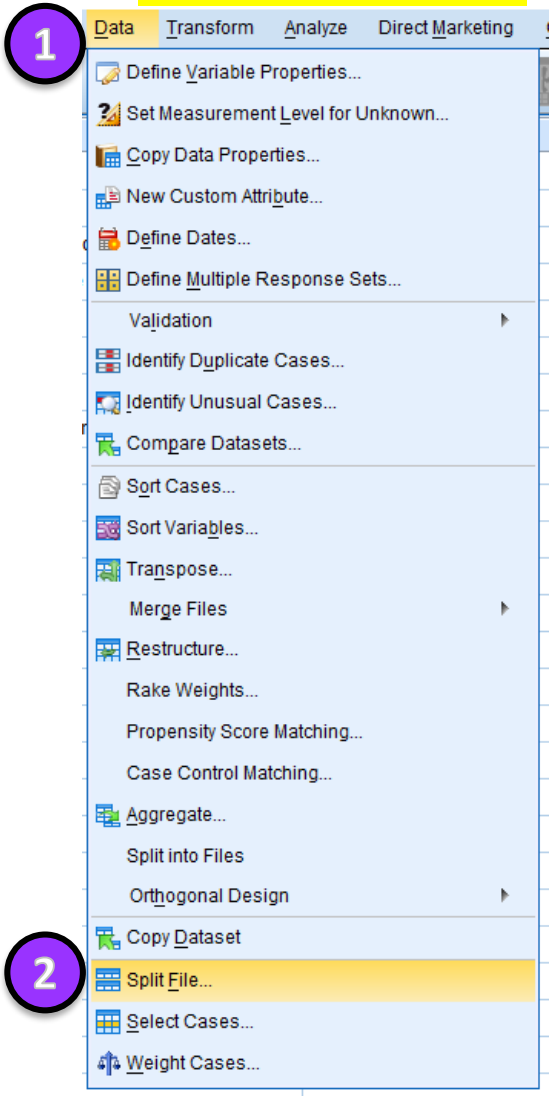


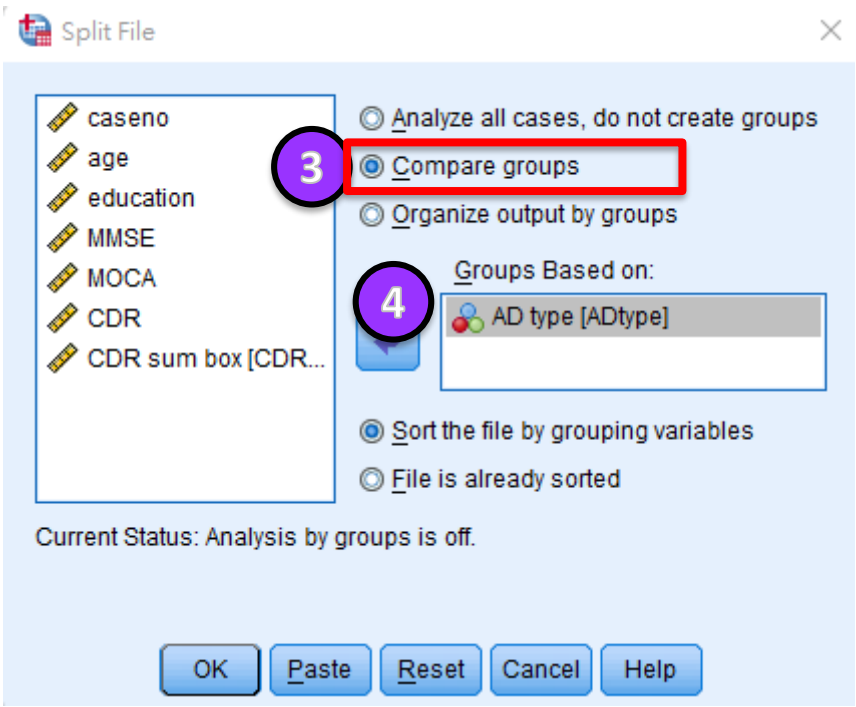




Kruskal-Wallis test SPSS analysis-2

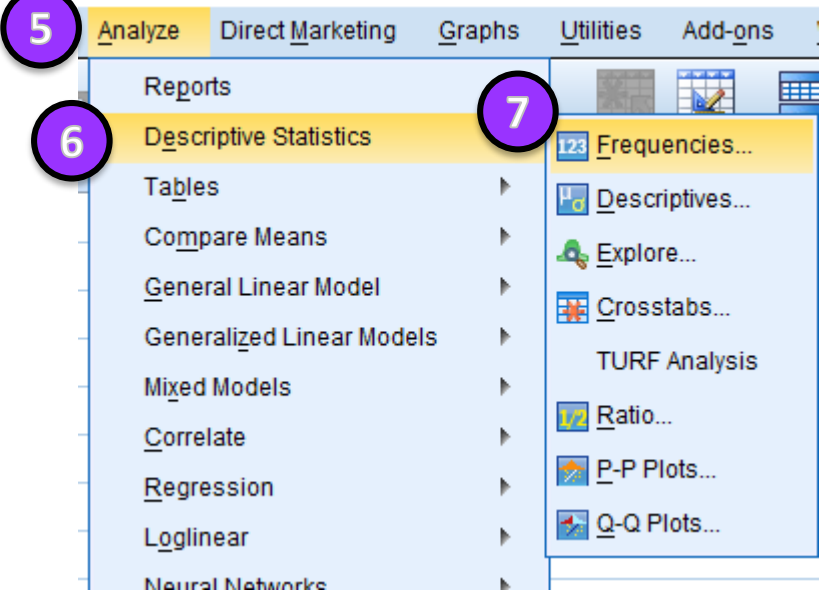
資料>分割檔案

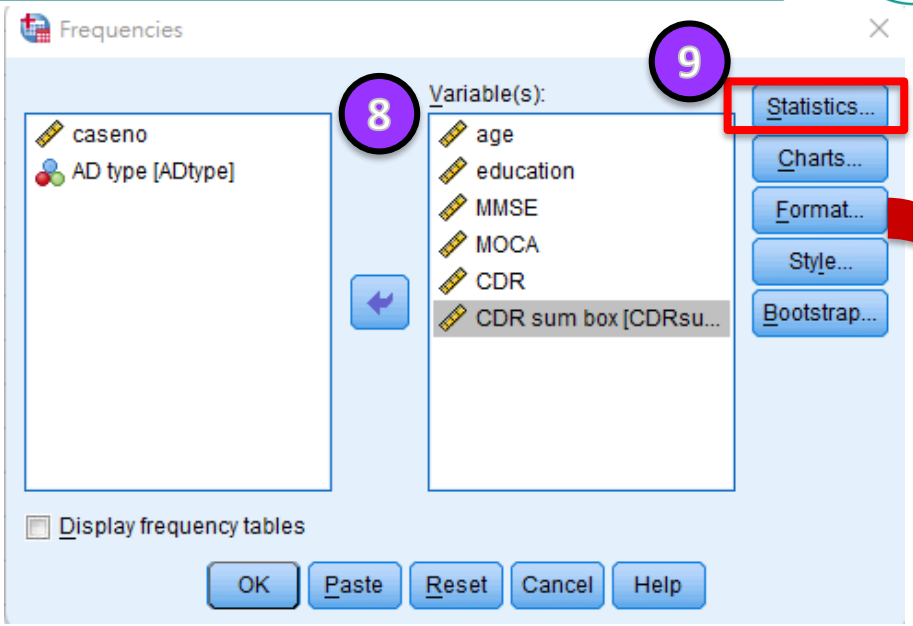


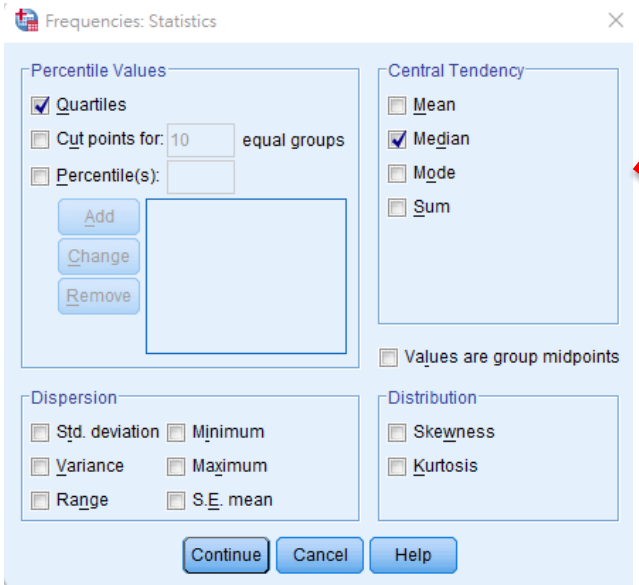


Kruskal-Wallis test SPSS analysis-3

分析>描述性資料>次數分配表







Kruskal-Wallis test SPSS output

Statistics

AD type			age	education	MMSE	MOCA	CDR	CDR sum box
Typical	N	Valid	33	33	33	22	32	32
		Missing	0	0	0	11	1	1
	Median		81.00	6.00	18.00	12.00	1.000	6.000
	Percentiles	25	74.50	6.00	12.50	9.50	.500	3.625
		50	81.00	6.00	18.00	12.00	1.000	6.000
		75	83.50	10.50	21.50	14.00	1.000	8.000
LP	N	Valid	26	26	25	17	25	25
		Missing	0	0	1	9	1	1
	Median		76.50	6.00	16.00	9.00	1.000	6.000
	Percentiles	25	65.75	6.00	12.50	6.50	.750	4.250
		50	76.50	6.00	16.00	9.00	1.000	6.000
		75	84.25	12.00	21.00	13.50	1.000	7.500
HS	N	Valid	40	40	40	31	39	39
		Missing	0	0	0	9	1	1
	Median		79.50	6.00	20.00	14.00	1.000	4.000
	Percentiles	25	76.00	6.00	16.00	10.00	.500	3.000
		50	79.50	6.00	20.00	14.00	1.000	4.000
		75	84.00	9.00	22.75	18.00	1.000	5.500
MA	N	Valid	38	38	38	32	36	36
		Missing	0	0	0	6	2	2
	Median		77.00	6.00	20.00	14.50	.500	4.500
	Percentiles	25	70.75	.00	14.00	8.25	.500	3.000
		50	77.00	6.00	20.00	14.50	.500	4.500
		75	79.00	12.00	22.50	18.75	1.000	5.375

Test Statistics[a,b]

	age	education	MMSE	MOCA	CDR	CDR sum box
Chi-Square	11.329	1.600	5.891	8.059	9.774	12.575
df	3	3	3	3	3	3
Asymp. Sig.	.010	.659	.117	.045	.021	.006

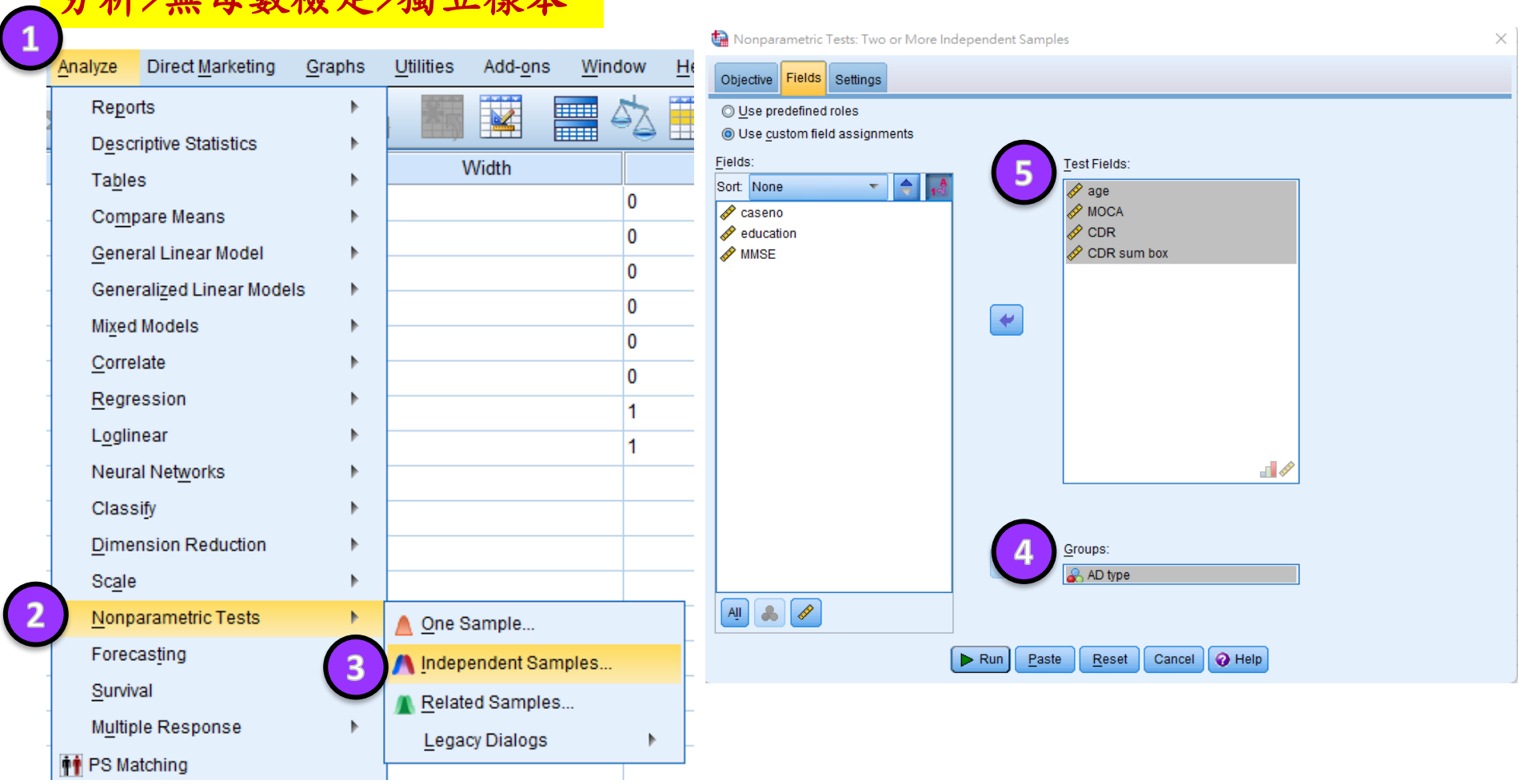
a. Kruskal Wallis Test

b. Grouping Variable: AD type

在MoCA的部分，
不同AD type程度有統計差異
MA的中位數高於其他 (p=0.045)

Kruskal-Wallis test SPSS post-hoc

分析>無母數檢定>獨立樣本



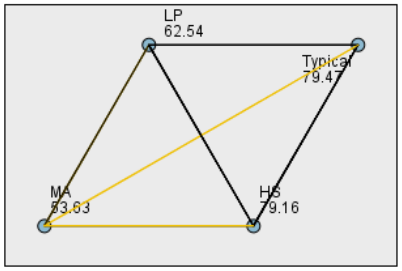
Kruskal-Wallis test SPSS post-hoc

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.	Decision
1	The distribution of age is the same across categories of AD type.	Independent-Samples Kruskal-Wallis Test	.010	Reject the null hypothesis.
2	The distribution of MOCA is the same across categories of AD type.	Independent-Samples Kruskal-Wallis Test	.045	Reject the null hypothesis.
3	The distribution of CDR is the same across categories of AD type.	Independent-Samples Kruskal-Wallis Test	.021	Reject the null hypothesis.
4	The distribution of CDR sum box is the same across categories of AD type.	Independent-Samples Kruskal-Wallis Test	.006	Reject the null hypothesis.

Asymptotic significances are displayed. The significance level is .05.

Pairwise Comparisons of AD type



Each node shows the sample average rank of AD type

Sample1-Sample2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj.Sig.
MA-LP	8.907	10.091	.883	.377	1.000
MA-HS	25.531	8.982	2.843	.004	.027
MA-Typical	25.838	9.434	2.739	.006	.037
LP-HS	-16.624	9.988	-1.664	.096	.576
LP-Typical	16.931	10.397	1.628	.103	.621
HS-Typical	.307	9.324	.033	.974	1.000

Each row tests the null hypothesis that the Sample 1 and Sample 2 distributions are the same.
Asymptotic significances (2-sided tests) are displayed. The significance level is .05.

Pairwise comparisons

組數超過兩組-Post Hoc Tests

- P-value < 0.05; 若拒絕虛無假設表示至少有一組平均值不相等，並非所有平均值均不相等
- 兩兩比較(pairwise comparison) :
  - 3 組(A,B,C)比較: (A v.s. B)(A v.s. C) (B v.s.C)
  - 4組比較：6種兩兩比較
- 至少一次檢定的p值小於0.05的機率 $1-(1-0.05)^n$
  - 4組比較 $1-(1-0.05)^6 = 0.26$

# of popl.	n	Overall Type I error
3	3	0.1426
4	6	0.2649
5	10	0.4013
6	15	0.5367

- 常見post hoc比較法
  - Scheffe method
  - Bonferroni method
  - Least squares difference method (LSD)

Correlation

- **Pearson correlation**
  - Normal distribution
  - Continuous
- **Spearman rank correlation**
  - Skewed distribution
  - Ordinal/ Continuous

Table 4
Correlations of ANA, anti-dsDNA antibody, C3, C4 and subcomponents of PANSS and UKU in schizophrenia patients with SLE or autoimmune features.

	ANA titer		Anti-dsDNA antibody		C3		C4	
	r_s	*p*	r_s	*p*	r_s	*p*	r_s	*p*
N4 (social withdraw)	0.108	0.402	−0.010	0.940	−0.258	0.047*	−0.148	0.257
P3 (hallucinatory behavior)	−0.031	0.811	−0.041	0.754	−0.213	0.103	−0.285	0.027*
G9 (unusual thought content)	0.160	0.213	−0.172	0.181	−0.166	0.204	−0.296	0.022*
P1 (delusion)	0.097	0.452	−0.019	0.885	−0.271	0.036*	−0.158	0.229
N6 (lack of spontaneity)	−0.051	0.693	−0.007	0.958	−0.318	0.013*	−0.005	0.969
N1 (blunted affect)	0.046	0.721	−0.104	0.422	−0.327	0.011*	−0.036	0.783
G5 (mannerisms/posturing)	0.016	0.899	−0.093	0.472	−0.189	0.148	−0.063	0.635
P2 (conceptual disorganization)	0.387	0.002**	−0.011	0.933	−0.225	0.083	−0.200	0.125
UKU (increased salivation)	0.187	0.146	0.055	0.671	−0.325	0.011*	−0.162	0.217

Spearman's rho coefficient.
PANSS: Positive and Negative Syndrome Scale.
UKU: Udvalg for Kliniske Undersøgelser rating scale.
* $p < 0.05$.
** $p < 0.01$.

說明：(相關係數數值範圍為-1~1)	
相關係數	相關程度
1	完全相關
0.7~0.99	高度相關
0.5~0.69	中度相關
0.25~0.49	低度相關
0~0.24	無相關

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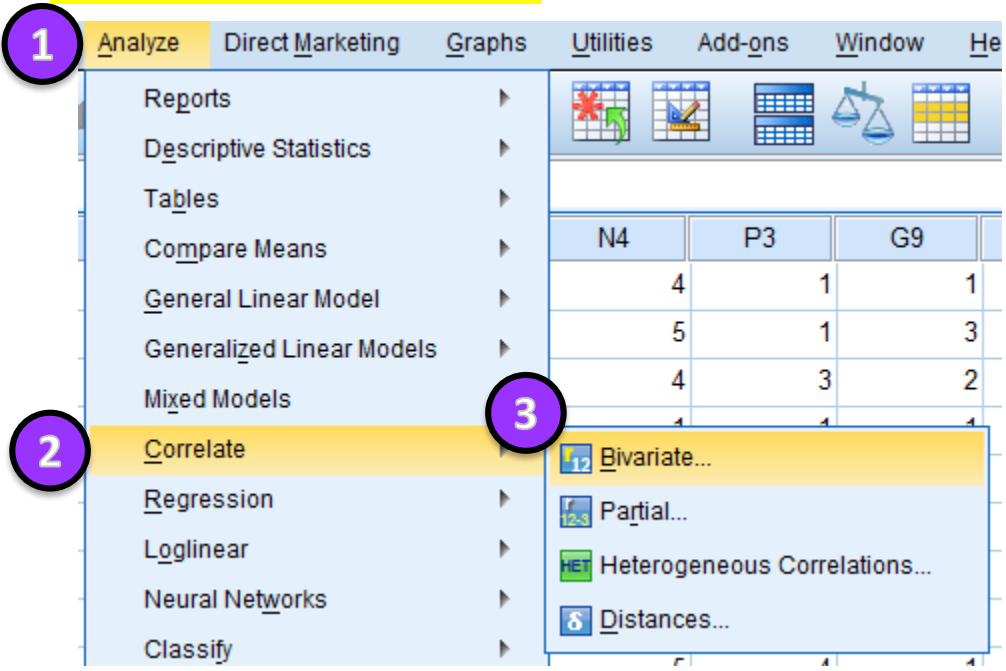
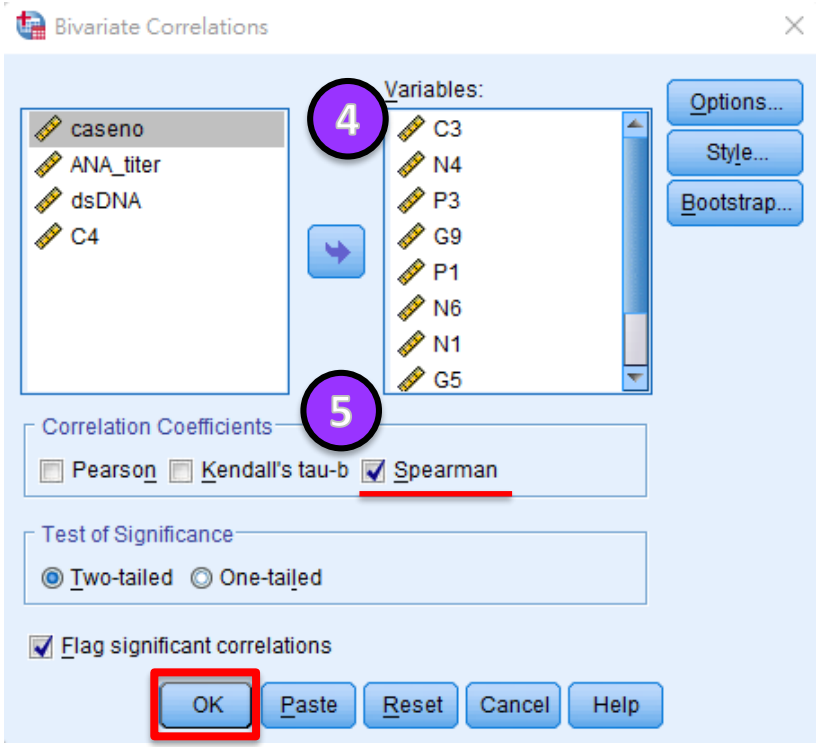
Correlation SPSS dataset

	caseno	ANA_titer	dsDNA	C3	C4	N4	P3	G9	P1
1	1	1280	77.946	97.6	23.3	4	1	1	1
2	2	160	21.197	140.7	28.2	5	1	3	2
3	3	160	68.895	122.4	37.6	4	3	2	1
4	4	160	40.632	114.3	24.1	1	1	1	1
5	5	160	6.306	113.7	18.8	5	2	2	2
6	6	320	166.537	63.7	9.5	4	2	3	3
7	7	640	207.814	84.4	10.9	6	2	2	2
8	8	80	141.294	95.3	20.6	5	6	1	3
9	9	640	19.552	107.0	19.1	5	4	1	1
10	10	160	15.728	113.9	21.4	2	4	2	2
11	11	320	161.745	107.3	19.4	2	1	1	1
12	12	80	220.212	138.6	27.9	4	1	1	1

Correlation SPSS analysis

分析>相關>雙變數





Correlation SPSS output

Correlations

			C3	N4	P3	G9	P1	N6	N1	G5	P2	UKU
Spearman's rho	C3	Correlation Coefficient	1.000	-.258*	-.213	-.166	-.271*	-.318*	-.327*	-.189	-.225	-.325*
		Sig. (2-tailed)	.	.047	.103	.204	.036	.013	.011	.148	.083	.011
		N	60	60	60	60	60	60	60	60	60	60
	N4	Correlation Coefficient	-.258*	1.000	.159	.200	.290*	.404**	.541**	.102	.382**	.016
		Sig. (2-tailed)	.047	.	.217	.119	.022	.001	.000	.429	.002	.899
		N	60	62	62	62	62	62	62	62	62	62
	P3	Correlation Coefficient	-.213	.159	1.000	.342**	.439**	.000	.010	.294*	.290*	.177
		Sig. (2-tailed)	.103	.217	.	.007	.000	1.000	.939	.020	.022	.170
		N	60	62	62	62	62	62	62	62	62	62
	G9	Correlation Coefficient	-.166	.200	.342**	1.000	.791**	-.047	.101	.315*	.309*	.085
		Sig. (2-tailed)	.204	.119	.007	.	.000	.716	.435	.013	.014	.512
		N	60	62	62	62	62	62	62	62	62	62
	P1	Correlation Coefficient	-.271*	.290*	.439**	.791**	1.000	.078	.217	.383**	.410**	.176
		Sig. (2-tailed)	.036	.022	.000	.000	.	.547	.091	.002	.001	.172
		N	60	62	62	62	62	62	62	62	62	62
	N6	Correlation Coefficient	-.318*	.404**	.000	-.047	.078	1.000	.616**	.273*	-.026	-.193
		Sig. (2-tailed)	.013	.001	1.000	.716	.547	.	.000	.032	.843	.133
		N	60	62	62	62	62	62	62	62	62	62
	N1	Correlation Coefficient	-.327*	.541**	.010	.101	.217	.616**	1.000	.067	.218	-.012
		Sig. (2-tailed)	.011	.000	.939	.435	.091	.000	.	.606	.088	.926
		N	60	62	62	62	62	62	62	62	62	62
	G5	Correlation Coefficient	-.189	.102	.294*	.315*	.383**	.273*	.067	1.000	.128	.033
		Sig. (2-tailed)	.148	.429	.020	.013	.002	.032	.606	.	.321	.801
		N	60	62	62	62	62	62	62	62	62	62
	P2	Correlation Coefficient	-.225	.382**	.290*	.309*	.410**	-.026	.218	.128	1.000	.257*
		Sig. (2-tailed)	.083	.002	.022	.014	.001	.843	.088	.321	.	.043
		N	60	62	62	62	62	62	62	62	62	62
	UKU	Correlation Coefficient	-.325*	.016	.177	.085	.176	-.193	-.012	.033	.257*	1.000
		Sig. (2-tailed)	.011	.899	.170	.512	.172	.133	.926	.801	.043	.
		N	60	62	62	62	62	62	62	62	62	62

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

Summary

有母數分析	無母數分析
➢ Independent T-test	➢ Mann-Whitney U test
➢ Paired T-test	➢ Wilcoxon signed-rank
➢ ANOVA	➢ Kruskal-Wallis test
➢ Pearson correlation	➢ Spearman rank correlation

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感謝您的聆聽！

Thank you !