CHAPTER 5

NON-PARAMETRIC TESTS

The methods described in chapter 4 are all based on the following assumptions:
1. Simple random sample.
2. The data is numeric.
3. The data is normally distributed.
4. For comparing two population means, it is assumed that the variances of the two populations underlying each of the samples are equal (Homogeneity of population variances).

These methods are referred to as *parametric* methods since their application involves estimating the parameters (mean, variance etc.) of the underlying distribution.

Many statistical tests require that your data follow a normal distribution. Sometimes this is not the case. In some instances it is possible to transform the data to achieve approximate Normality. For example, for a variable measured on an *interval* scale, taking the logarithm of the data values may render approximate Normality. In other cases this is not possible or the sample size might be so small that it is difficult to ascertain whether or not the data a normally distributed. In such cases it is necessary to use a statistical test that does not require the data to follow a particular distribution. Such a test is called a *non-parametric* or *distribution free test*.

The methods of chapters 4 are also appropriate for data measured on an *interval* scale. However, for data recorded on an *ordinal* scale, or worse, on a *nominal* scale, these tests are inappropriate. For data on an ordinal scale, tests based upon the *ranks* of the data have been developed. (Note that many of the distribution-free tests are also rank tests.) For nominal data, more restrictive (or less powerful) tests are also available, such as the chi-squared (χ^2) test. It is preferable to use a parametric test over a nonparametric test, since parametric tests are more powerful. However, we should use nonparametric tests when the sample data do not meet the required assumptions that underlie the parametric tests.

There are numerous nonparametric tests available, and SPSS includes most of them. Here in this chapter we will describe some of these tests which serve as non-parametric counterparts to the Student's t tests and ANOVA described in Chapter 4 for comparing two means.

The *Nonparametric Tests* option of the *Analyze* menu offers a wide range of non-parametric tests, as illustrated in Figure 5.1 below.

5.1 Sign Test: One Sample (Single set of observations)

The sign test is used to test the null hypothesis that the median of a distribution is equal to some value. The sign test can be used for testing:
- One-sample T-test
- Paired T-test

- Ordered categorical data where a numerical scale is inappropriate but where it is possible to rank the observations.

The binomial test is useful for determining if the proportion of people in one of two categories is different from a specified amount.

Example 5.1:

If we asked people to select one of two tea types, A or B, we could determine if the proportion of people who selected a type A is different from.5. (That is, is the proportion of people who selected a type A different from the proportion of people who selected a type B.)

SPSS assumes that the variable that specifies the category is numeric. If the variable is string then we should recode the variable before we can perform the binomial test. You may use automatically recoding variable technique. Automatically recode is described in Chapter 1.

As always, we will perform the basic steps in hypothesis testing:

1. State the null and alternative hypotheses: H_0: P =.5 versus H_1: P $\neq$.5, where P is the proportion of people who selected type A.
2. Determine if the hypotheses are one- or two-tailed. These hypotheses are two-tailed as the null is written with an equal sign.
3. Specify the α level: α =.05
4. Perform the statistical test.

SPSS Step by Step:

- Click **Analyze $\Rightarrow$ Nonparametric Tests $\Rightarrow$ Binomial** as shown in Figure 5.1.
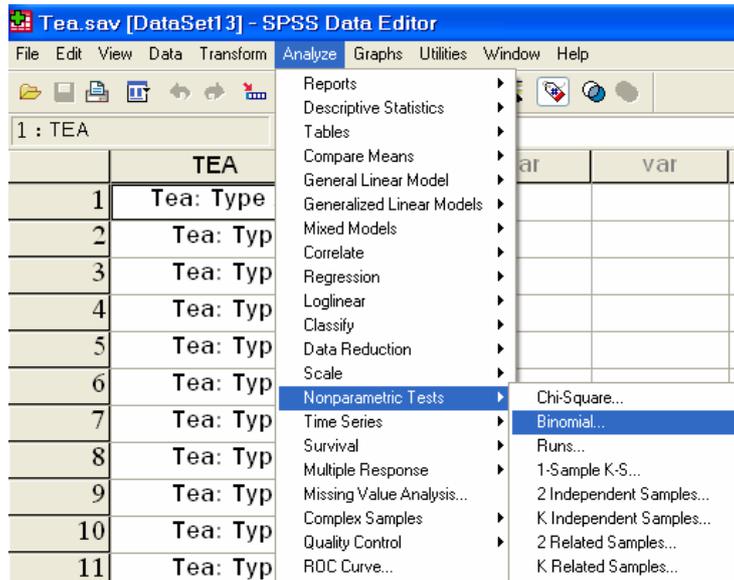
Figure 5.1: Non-Parametric Tests

The Binomial dialog box appears.

- Click the variable of interest from the list at the left by clicking on it, and then move it into the Test Variable List by clicking on the arrow button. In this example, we select the variable TEA and moved it into the *Test Variable List* box.
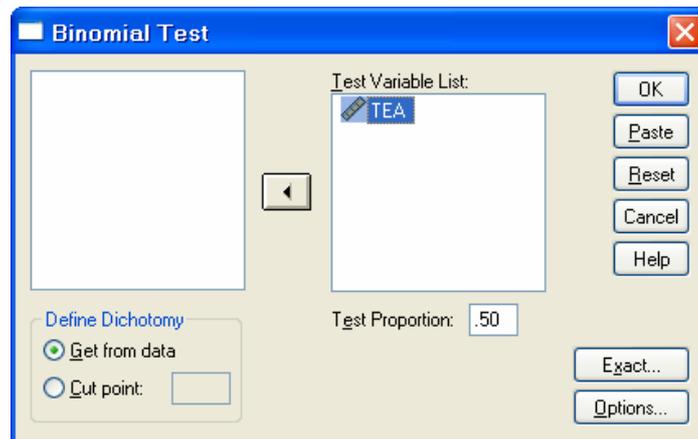- Enter.50 in as a value of Test Proportion box (if it does not already contain it) as illustrated in Figure 5.2.

Figure 5.2: Binomial Test

- Click on the OK button to perform the test. The SPSS output viewer appears with the binomial output as illustrated in Figure 5.3.:

Binomial Test

		Category	N	Observed Prop.	Test Prop.	Asymp. Sig. (2-tailed)
TEA	Group 1	Tea: Type A	33	.66	.50	.033[a]
	Group 2	Tea: Type B	17	.34		
	Total		50	1.00		

a. Based on Z Approximation.

Figure 5.3: Result of Binomial Test

<u>**Conclusion:**</u>

The output tells us that there are two groups: Type A and Type B. The column labeled N tells us that there were 33 people who reported that they would prefer a type A and 17 people who reported that they would prefer a type B.

The *Observed Prop.* column gives the observed proportions (.66 = 33/ (33 + 17). The next column, Test Prop., gives the value that you entered in the Test Proportion box in the Binomial Test dialog box. The last column, *Asymp. Sig. (2-tailed)*, gives the p value for this statistical test. As always, when the p value is less than or equal to your α level, you can reject H_0.

Decide whether to reject H_0. The p value in this example is.033 which is less than α level of.05. Thus, we reject H_0 that the mean proportion of people who would prefer a type A as a Tea is equal to.5.

Note:
For Binomial test, SPSS includes values that are exactly equal to the median — it takes
 r+ = the number of observations that are greater than M and
 r- = the number of observations that are less than or equal to M. Any ties should therefore be excluded manually as follows.

Example 5.2:
The Hemoglobin for 15 children are shown below:

13.5, 11.7, 8.9, **8.0**, 12.9, 6.7, 7.1, 6.3, 9.4, 8.2, 8.5, 7.5, 8.7, 8.2, 8.1

Test to see if the Hemoglobin equals 8.

- Open the SPSS data file called **Hemoglobin**
- Check the normality for the distributions of Hemoglobin for the 15 children. The histogram and Shapiro-Wilk tests of Normality are shown in Figure 5.4. It is clear that the distribution of Hemoglobin is skewed to the right. Significance (P-value) of Shapiro-Wilk statistic is equal to 0.023 which is smaller than $\alpha = 0.05$, then we reject the null hypothesis that says the Hemoglobin is normally distributed.

This data should be analyzed using the nonparametric techniques. Thus, these data are more appropriately analyzed using the nonparametric Sign test than the parametric independent samples.
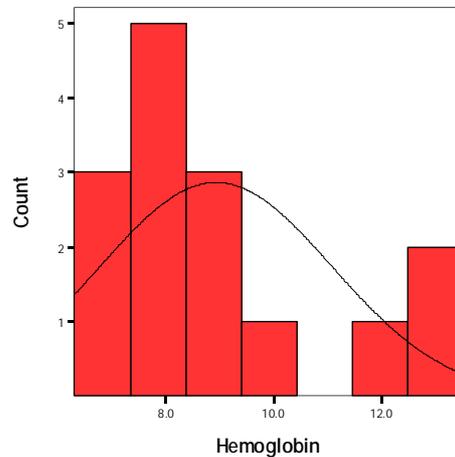
Tests of Normality

	Kolmogorov–Smirnov[a]			Shapiro–Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Hemoglobin	.236	15	.024	.858	15	.023

a. Lilliefors Significance Correction

Figure 5.4: Histogram and Tests of Normality

<u>**SPSS Step by Step:**</u>
- Click on **Data $\Rightarrow$ Select Cases $\Rightarrow$ If condition is satisfied $\Rightarrow$ click on If**
- In the box type in your variable name then $\neq$ M, where M is the median value specified in your null hypothesis; in this case M=8
- Click on Continue then OK.

To perform the sign test, follow the following steps:

- Click on **Analyze $\Rightarrow$ Nonparametric Tests $\Rightarrow$ Binomial…**
- Choose the *Hemoglobin* as the Test Variable
- Under *Define Dichotomy* in the lower left hand corner of the pop-up screen, choose
  Cut Point and specify your null value (i.e. 8.0 in the case of paired data, etc.) as shown in Figure 5.5.
- Click on OK. The output will look like Figure 5.6.

<u>**Conclusion:**</u>
Since Sig. (P-value) = 0.180, then we reject the null hypothesis. We would conclude that there is insufficient evidence to conclude that the Hemoglobin is different from 8.0.

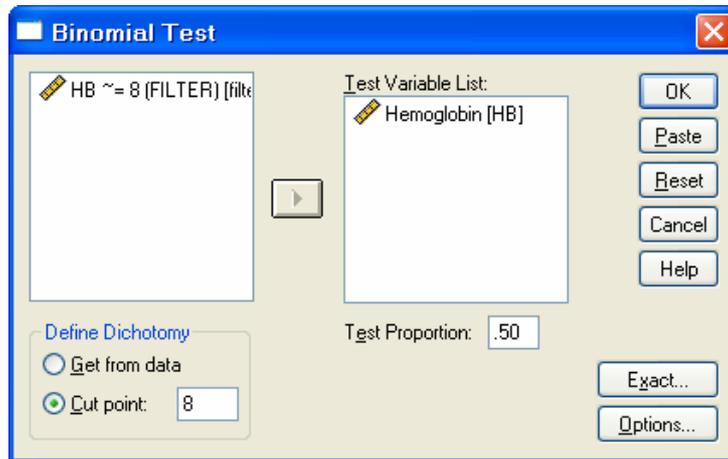Note: This conclusion is the same as we got by using paired samples T-test.

Figure 5.5: Binomial Test Windows

Binomial Test

		Category	N	Observed Prop.	Test Prop.	Exact Sig. (2-tailed)
Hemoglobin	Group 1	<= 8	4	.29	.50	.180
	Group 2	> 8	10	.71		
	Total		14	1.00		

Figure 5.6: Result of Binomial Test

5.2   Mann-Whitney Test: Two Independent Samples

The Mann-Whitney test for testing independent samples is a non-parametric test that is useful for determining if there exist significant differences between two independent samples. The Mann-Whitney test is the nonparametric version of the two-independent samples test described in Chapter 4. It is often used when the assumptions of the T-test have been violated. Thus it is useful if:

- The dependent variable is ordinal scaled instead of interval or ratio.
- The assumption of normality has been violated in a T-test (especially if the sample size is small.)
- The assumption of homogeneity of population variances has been violated in a T-test.

As the total number of observations in the two samples increases, the distribution of the Mann-Whitney U test statistic can be approximated by the Normal distribution.

SPSS assumes that the independent variable is represented numerically. In any sample data set, we must first convert the independent variable from a string variable to a numerical

Example 5.3:

Recall the data from AIDS file. In that data set, we have information about AIDS rates for different world health organization regional office. Suppose we want to test if Europe's AIDS rate is higher than AIDS rate for Eastern Mediterranean in 1992.

Var.	Description
WHOReg	World Health Organization Regional Office
	1 = Africa, 2 = Americas, 3 = Eastern Mediterranean
	4 = Europe, 5 = South-East Asia, 6 = Western Pacific
Rate92	Cases per 100,000 population, 1992

Before performing the test, let's do the following:
- Open the SPSS data file called **AIDS**.
- Use **Select Cases** to choose Eastern Mediterranean and Europe from the WHOReg. (Select cases is discussed in Chapter 1).
- Check the normality for the distributions of AIDS rates for Eastern Mediterranean and Europe. The histograms for the two groups are shown in Figure 5.7. It is clear that the two distributions are skewed to the right and have comparable shape, which are definitely not normal. These data should be analyzed using the nonparametric techniques. Thus, these data are more appropriately analyzed using the nonparametric Mann-Whitney U test than the parametric independent samples.
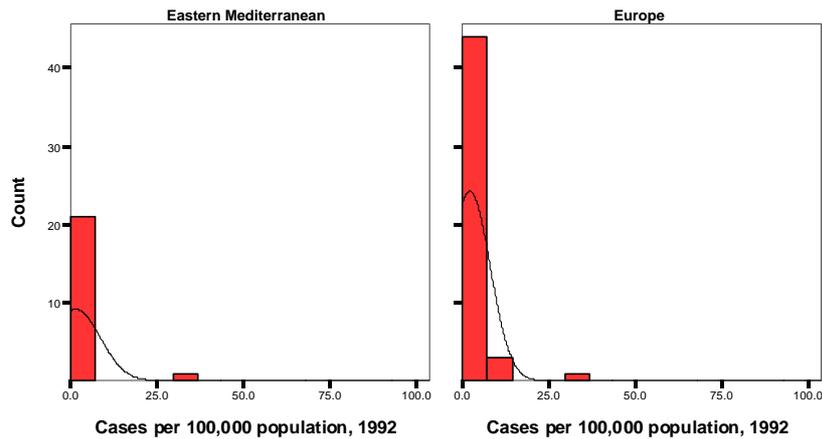

Figure 5.7: Histograms for Eastern Mediterranean and Europe.

As always, we will perform the basic steps in hypothesis testing:

We will follow the following steps:

1.   State the null and alternative hypotheses: $H_0 : \mu_{Europe} = \mu_{E.Med}$ versus

$H_a : \mu_{Europe} > \mu_{E.Med}$

2. Specify the α level. For example choose α =.05.

3. Determine the appropriate statistical test. In this case, AIDS rates is approximately ratio scaled, and we have multiple (2) groups, so the Mann-Whitney test is appropriate.

4. Use SPSS to perform the Mann-Whitney U test.

SPSS Step by Step:

- Click on **Analyze⟹ Nonparametric Tests⟹ 2 Independent Samples…** The Two-Independent-Samples Test dialog box will appear.
- Click **rate92** and transfer it to the *Test Variable List*.
- Click **whoreg** and transfer it to the box labeled *Grouping Variable*.
- There are several types of tests to choose from in the dialog box but we will agree with the default test, the **Mann-Whitney U**.
- You need to tell SPSS how to define the two groups. Click on the <**Define Groups**> button. The Define Groups dialog box appears. In the window displayed, (shown in Figure 5.8)**,** enter values 3 and 4 for Groups 1 and 2 respectively. We will call the Eastern Mediterranean Group 1 (they are coded 3 in the data file) and we will call the Europe Group 2 (they are coded 4).
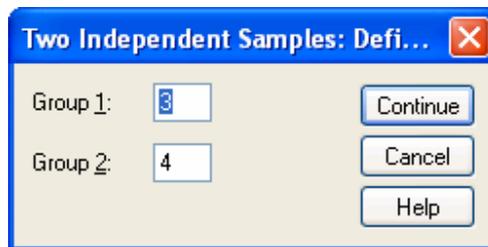

Figure 5.8: Defining Groups for Mann-Whiteny Test

- Click on **<Continue>** button to close the Define Groups dialog box.

The Independent Samples Mann-Whitney test window should now look like Figure 5.9.
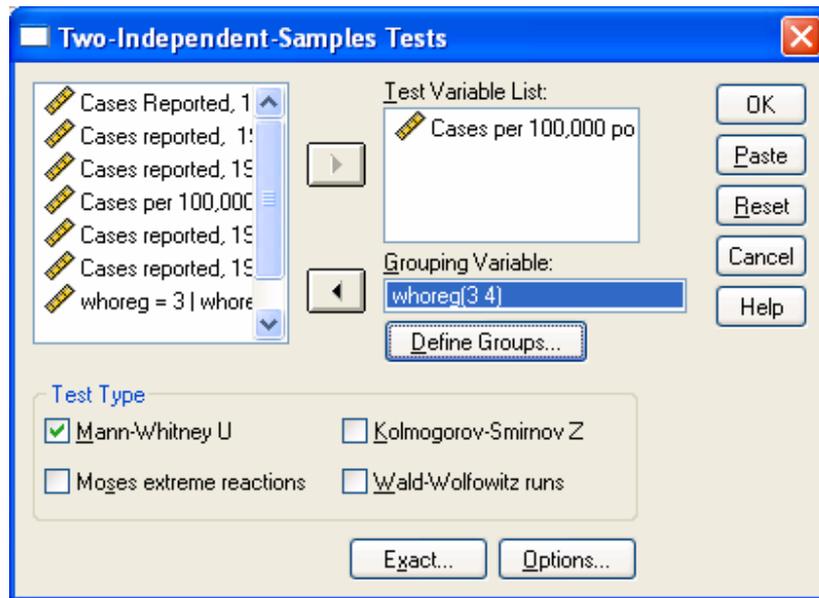
Figure 5.9: Two-Independent Samples Test Window

- Click on **<OK>** button in the two-Independent-Samples Tests dialog box to perform the Mann-Whitney test. The results have two main parts: Ranks statistics and inferential statistics.

Conclusion:

The first part of the output gives the means and sums of ranks within each group, (shown in Figure 5.10).

Ranks

	WHO Region	N	Mean Rank	Sum of Ranks
Cases per 100,000 population, 1992	Eastern Mediterranean	22	28.36	624.00
	Europe	48	38.77	1861.00
	Total	70		

Figure 5.10: Summary Statistics for Ranks

This part gives some summary information about the two groups. In this example, there are 22 countries in the Eastern Mediterranean, with mean rank of 28.36. There are 48 countries in Europe (N), with mean rank of 38.77. The last column gives the sum of ranks for each of the two groups.

The second part of the output gives the result of Mann-Whitney test, (shown in Figure 5.11).

Test Statistics[a]

	Cases per 100,000 population, 1992
Mann-Whitney U	371.000
Wilcoxon W	624.000
Z	-2.038
Asymp. Sig. (2-tailed)	.042

a. Grouping Variable: WHO Region

Figure 5.11: Result of Mann-Whitney Test

The Mann-Whitney U statistic is equal to 371.00 with significance (P-value) equal to 0.042. Thus, we conclude that there is a significant difference in the mean AIDS rate between Eastern Mediterranean and Europe. One would conclude that Europe AIDS rate is significantly higher than Eastern Mediterranean since the mean ranks are 28.36 and 38.77 for Eastern Mediterranean and Europe, respectively.

Example 5.4:
The data in Table 5.1 represent the biceps skinfold thickness (mm) in two groups of patients.
We are interested to test if there exists significant difference between the two groups.

Crohn's Disease				Coeliac Disease	
1.8	2.8	4.2	6.2	1.8	3.8
2.2	3.2	4.4	6.6	2.0	4.2
2.4	3.6	4.8	7.0	2.0	5.4
2.5	3.8	5.6	10.0	2.0	7.6
2.8	4.0	6.0	10.4	3.0	

Table 5.1: Biceps skinfold thickness data

SPSS Step by Step:
- Open the SPSS data file called **skinfold**. Note that the variable **Group** indicates the disease group to which the patient belongs.
- Check the normality for the distributions of biceps skinfold thickness (mm) in two groups of patients. The histograms for the two groups are shown in Figure 5.12. It is clear that the two distributions are skewed to the right and have comparable shape. Thus, these data are more appropriately analyzed using the nonparametric Mann-Whitney U test than the parametric independent samples.
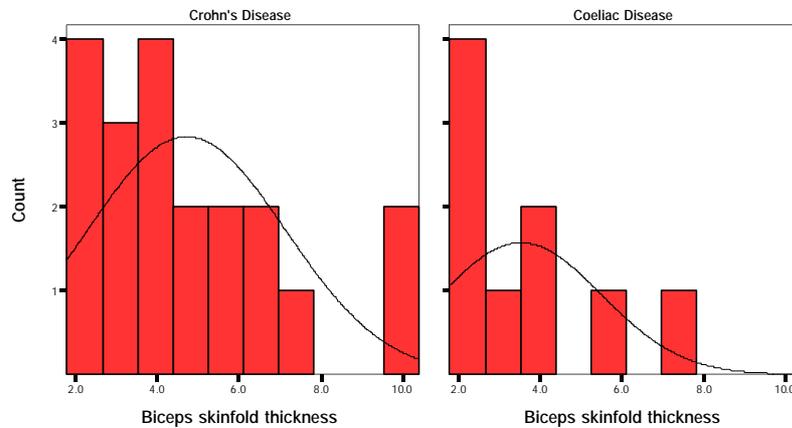
Figure 5.12: Histograms for the two groups (Crohn's and Coeliac Diseases)

Carry out a Mann-Whitney test as we described in Example 5.3.

Conclusion:
The first part, (shown in Figure 5.13), gives some summary information about the two groups. In this example, there are 20 patients in Crohn's disease, with mean rank of 16.53. There are 9 patients in Coeliac disease group, with mean rank of 11.61. The last column gives the sum of ranks for each of the two groups.

Ranks

	Disease Group	N	Mean Rank	Sum of Ranks
Biceps skinfold thickness	Crohn's Disease	20	16.53	330.50
	Coeliac Disease	9	11.61	104.50
	Total	29		

Figure 5.13: Summary Statistics for Ranks

The second part of the output gives the result of Mann-Whitney test, (shown in Figure 5.14). The Mann-Whitney U statistic is equal to 59.50 with significance (P-value) equal to 0.153. Thus, we conclude that there is insignificant difference between the two patient's groups.

Test Statistics [b]

	Biceps skinfold thickness
Mann–Whitney U	59.500
Wilcoxon W	104.500
Z	–1.439
Asymp. Sig. (2–tailed)	.150
Exact Sig. [2*(1–tailed Sig.)]	.153 [a]

a. Not corrected for ties.

b. Grouping Variable: Disease Group

5.3 Sign Test: Two Related Samples (Paired Data)

The Sign test for testing related samples is a non-parametric test that is useful for determining if the paired mean difference is different from each other. The Sign test is the nonparametric version of the paired samples t test. It is often used when the assumptions of the paired samples T-test have been violated. We use this test if we have repeated measures of one sample and the population is not normally distributed. This test can be used with ordinal and numerical data.

Example 5.5:
The data in Table 5.2 shows the hours of relief provided by two analgesic drugs in 12 patients suffering from arthritis. Is there any evidence that one drug provides longer relief than the other?

Case	Drug A	Drug B
1	2.00	3.50
2	3.60	5.70
3	2.60	2.90
4	2.60	2.40
5	7.30	9.90
6	3.40	3.30
7	14.90	16.70
8	6.60	6.00
9	2.30	3.80
10	2.00	4.00
11	6.80	9.10
12	8.50	20.90

Table 5.2: Drug's Data

SPSS Step by Step:
- Analyze $\Rightarrow$ Nonparametric Tests $\Rightarrow$ 2 Related Samples…
- Click Drug_A and Drug_B then click on the arrow to transfer them under *Test Pair(s) List*:
- Under *Test Type* select *Sign* as shown in Figure 5.15.
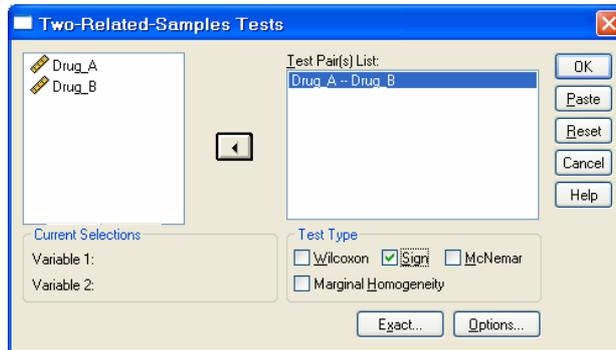- Click on OK. The output will look like Figure 5.16.

Figure 5.15: Two-Related-Samples Tests: Sign Test

Frequencies

		N
Drug_B - Drug_A Negative Differences[a]		3
Positive Differences[b]		9
Ties[c]		0
Total		12

a. Drug_B < Drug_A

b. Drug_B > Drug_A

c. Drug_B = Drug_A

Test Statistics[b]

	Drug_B - Drug_A
Exact Sig. (2-tailed)	.146[a]

a. Binomial distribution used.

b. Sign Test

Figure 5.16: Result of Sign Test

Conclusion:

The first part of the output summarized the results. Negative differences refer to the subjects whose Drug_B was less than Drug_A. Positive differences refer to the subjects whose Drug_B was higher than Drug_A. In this case there was no subject whose Drug_A was the same as Drug_B. The significance (P-value) = 0.146, then we do not reject the null hypothesis. We would conclude that there is no evidence for a difference between the two treatments.

Note:
- Note: If P-value is smaller then 0.05 then we reject the null hypothesis in favor of the alternative hypothesis. In this case one may use the mean rank for positive and negative ranks to know which one is higher.

- If you were carrying out a one-sided test, you would need to divide the p-value by 2.
- (Note that the Wilcoxon Signed Rank Sum Test (Will be discussed later) is also appropriate in these situations and is a more powerful test than the sign test because it takes account of the magnitude of the differences as well as the sign.)

5.4 Wilcoxon Signed Ranks Test: Two Related Samples

The Wilcoxon signed ranks test is the nonparametric version of the paired samples t test. It is often used when the assumptions of the paired samples T-test have been violated. We use this test if we have repeated measures of one sample and the population is not normally distributed. This test can be used with ordinal and numerical data.

This test takes into account information about the magnitude of differences within pairs and gives more weight to pairs that show large differences than to pairs that show small differences. The test statistic is based on the ranks of the absolute values of the differences between the two variables.

Example 5.6:
For purposes of an example, we will perform a Wilcoxon signed ranks test on change in the average rate data form the AIDS data. Specifically, we are interested to see if there was any significant change in the average rate of AIDS cases from 1992 to 1993.

<u>**SPSS Step by Step:**</u>
- Open the SPSS data file called **AIDS**
- Analyze$\Rightarrow$ Nonparametric Tests$\Rightarrow$ 2 Related Samples…
- Click *rate92* and *rate93* then click on the arrow to transfer them under *Test Pair(s) List*:
- Under *Test Type* select *Wilcoxon* as shown in Figure 5.17.
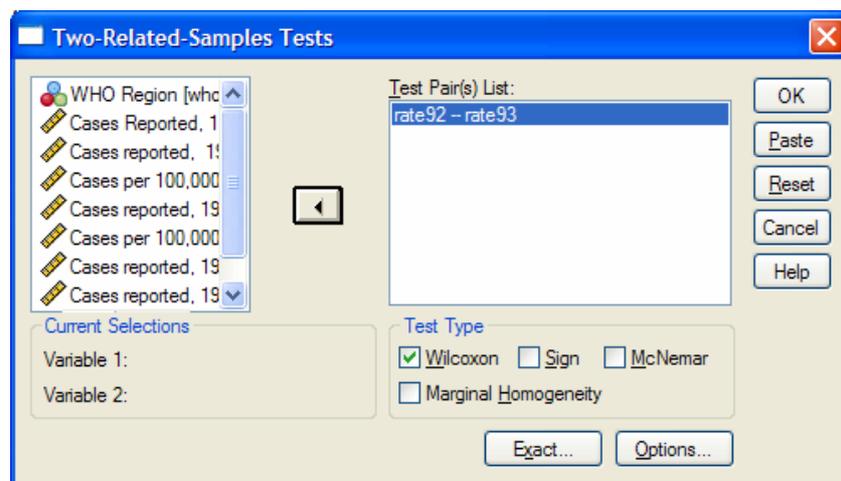- Click on OK. The output will look like Figure 5.18.

Figure 5.17: Two-Related-Samples Tests: Wilcoxon Test

Ranks

		N	Mean Rank	Sum of Ranks
Cases per 100,000 population, 1993 – Cases per 100,000 population, 1992	Negative Ranks	56[a]	79.33	4442.50
	Positive Ranks	89[b]	69.02	6142.50
	Ties	62[c]		
	Total	207		

a. Cases per 100,000 population, 1993 < Cases per 100,000 population, 1992

b. Cases per 100,000 population, 1993 > Cases per 100,000 population, 1992

c. Cases per 100,000 population, 1993 = Cases per 100,000 population, 1992

Test Statistics[b]

	Cases per 100,000 population, 1993 – Cases per 100,000 population, 1992
Z	-1.678[a]
Asymp. Sig. (2-tailed)	.093

a. Based on negative ranks.

b. Wilcoxon Signed Ranks Test

Figure 5.18: Result of Wilcoxon Test

Conclusion:

The first part of the output summarized the results. Negative ranks refer to the subjects whose

average rate of AIDS cases from 1993 were less than average rate of AIDS cases from 1992. Positive ranks are those subjects whose average rate of AIDS cases from 1993 was higher than average rate of AIDS cases from 1992. In this case there were subjects whose average rate of AIDS cases were the same for 1992 and 1993. Notice the mean rank for the Negative ranks and Positive ranks are 79.33 and 69.02, respectively. The Wilcoxon signed ranks statistics, converted to a z-score, is equal to -1.678 with a significance (P-value) equal to 0.093. Thus there is insufficient evidence to conclude the average rate of AIDS cases changes significantly from 1992 to 1993 at the 5% significance level.

Example 5.7:

The data in Table 5.3 represent the numbers of attacks of angina experienced by patients in a drug trial. The data are taken from Bland (2000).

Placebo	Pronethalol
2	0
17	15
3	0
7	2
8	1
14	7
23	16
34	25
79	65
60	41
323	348
71	29

Table 5.3: Angina Drug Trial data

SPSS Step by Step:
- Open the SPSS data file called **angina**.
- Check the normality for the distributions of the numbers of attacks of angina experienced by patients in a drug trial. The histograms for the two groups are shown in Figure 5.19. Histograms for Placebo and Pronethalol data indicate very strong departure from Normality in these measurements for each of the treatment groups. Thus, these data are more appropriately analyzed using the nonparametric Wilcoxon test than the parametric related samples.
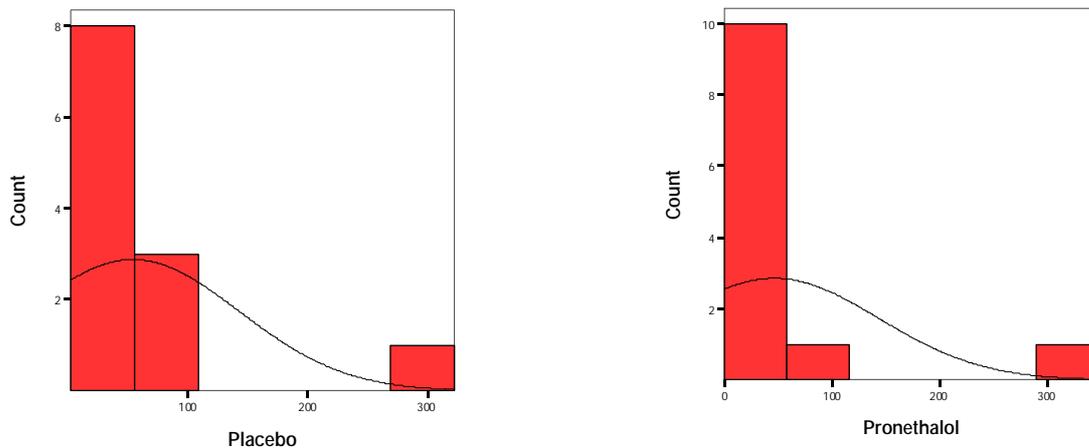

Figure 5.19: Histograms for the Placebo and Pronethalol data

Carry out a Wilcoxon test as we described in Example 5.6.

Conclusion:
The output shown in Figure 5.20. Negative ranks refer to patients whose number of attacks of angina using Pronethalol drug trial was smaller than Placebo drug trial. Positive ranks refer to patients whose number of attacks of angina using Pronethalol drug trial greater greater than Placebo drug trial. In this case there were not patients whose number of attacks of angina using Pronethalol were the same for Placebo drug trial. Notice the mean rank for the Negative ranks and Positive ranks are 6.09 and 11.00, respectively.

Ranks

		N	Mean Rank	Sum of Ranks
Pronethalol – Placebo	Negative Ranks	11[a]	6.09	67.00
	Positive Ranks	1[b]	11.00	11.00
	Ties	0[c]		
	Total	12		

a. Pronethalol < Placebo

b. Pronethalol > Placebo

c. Pronethalol = Placebo

Test Statistics[b]

	Pronethalol - Placebo
Z	-2.201[a]
Asymp. Sig. (2-tailed)	.028

a. Based on positive ranks.

b. Wilcoxon Signed Ranks Test

Figure 5.20: Result of Wilcoxon Test

The Wilcoxon signed ranks statistics, converted to a z-score, is equal to -2.201 with a significance (P-value) equal to 0.028. Thus there is sufficient evidence to conclude that a difference has been detected between the means of the two treatment groups at the 5% significance level.

5.5 Kruskal-Wallis H Test: Three or More Independent Samples

The Kruskal Wallis H test is used when you have one independent variable with two or more levels and an ordinal dependent variable. In other words, it is the non-parametric version of one-factor independent measures ANOVA described in Chapter 4 and a generalized form of the Mann-Whitney test method since it permits two or more groups. We use Kruskal-Wallis test when the independent samples come from populations with the same shape, although not necessarily normal. The Kruskal Wallis H test can be used with ordinal, interval, or ratio data. It is often used when the assumptions of the one-factor independent measures ANOVA have been violated. Thus it is useful if:

- The dependent variable is ordinal scaled instead of interval or ratio.
- The assumption of normality has been violated in ANOVA (especially if the sample size is small.)
- The assumption of homogeneity of population variances has been violated in ANOVA test.

The null hypothesis states that there are no significant differences among the levels of the independent variable.

Example 5.8:

Recall the data from **AIDS** file. In that data set, we have information about AIDS rates for different world health organization regional office. Did all six WHO regions experience roughly the same AIDS rate of cases in 1993?

Var.	Description
WHOReg	World Health Organization Regional Office
	1 = Africa, 2 = America, 3 = Eastern Mediterranean
	4 = Europe, 5 = South-East Asia, 6 = Western Pacific
Rate93	Cases per 100,000 population, 1993

SPSS Step by Step:
- Open the **AIDS** data file
- Check the assumption of normality. The histograms for the six regions are shown in Figure 5.21. It is clear that the six histograms not normal in shape, they are skewed to the right and have comparable shape. Thus, these data are more appropriately analyzed using the nonparametric Kruskal-Wallis H test than the one-factor independent measures ANOVA.
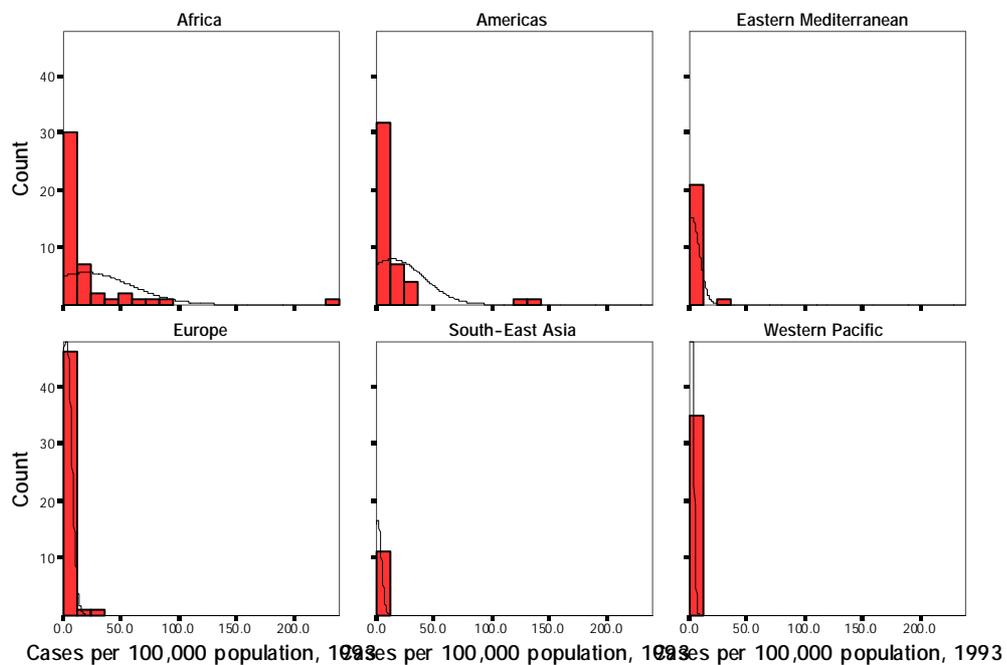

Figure 5.21: Histograms for the Six WHO Regions

SPSS Step by Step:

- Open the SPSS data file called **AIDS**.
- Click on **Analyze⟹ Nonparametric Tests⟹ K Independent Samples…** The Tests for Several Independent Samples dialog box will appear.
- Click **rate93** and transfer it to the *Test Variable List*.
- Click **whoreg** and transfer it to the box labeled *Grouping Variable*.
- There are several types of tests to choose from in the dialog box but we will agree with the default test, the **Kruskal-Wallis H test**.

- You need to tell SPSS how to define the two groups. Click on the <**Define Range**> button. The Define Range dialog box appears. In our data file, the six groups are labeled from 1 to 6. In the window displayed, (shown in Figure 5.22)**,** enter values 1 and 6 for Groups Minimum and Maximum respectively.
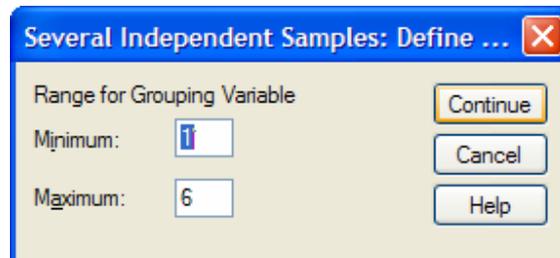

Figure 5.22: Defining Groups for Kruskal-Wallis H Test

- Click on <**Continue**> button to close the Define Groups dialog box.

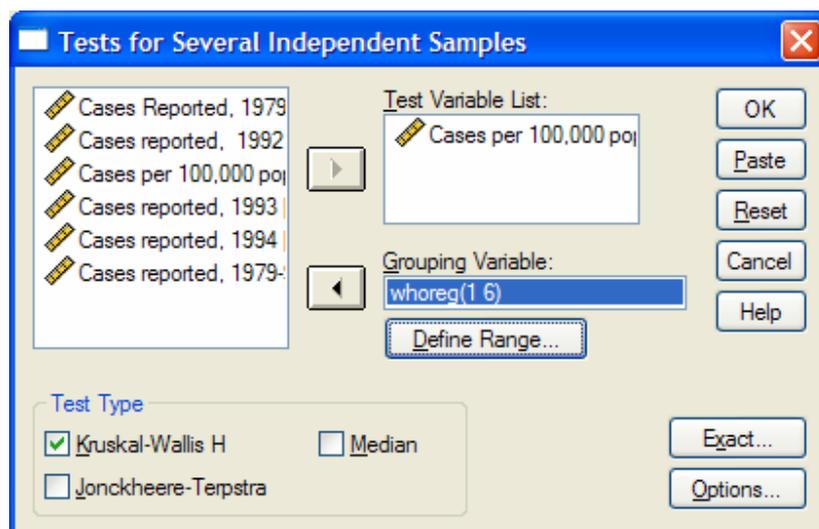The Tests for Several Independent Samples dialog box will now look like Figure 5.23.

Figure 5.23: Test for Several Independent Samples Test Window

- Click on <**OK**> button in the dialog box to perform the Kruskal-Wallis H test. The results have two main parts: Ranks statistics and inferential statistics.

<u>Conclusion:</u>

The first part, (shown in Figure 5.24), gives some summary information about the six groups. In this example, there are 46 countries in Africa, with mean rank of 138.82, 45 countries in Americas with mean rank of 142.32,…, and 35 countries in Western Pacific with mean rank of 64.76. These ranking appear quite different but we still have to rely on the statistical test to determine whether this sense is correct.

Ranks

	WHO Region	N	Mean Rank
Cases per 100,000 population, 1993	Africa	46	138.82
	Americas	45	142.31
	Eastern Mediterranean	22	71.50
	Europe	48	89.67
	South-East Asia	11	54.09
	Western Pacific	35	64.76
	Total	207	

Figure 5.24: Summary Statistics for Mean Ranks

The second part, (shown in Figure 5.25) of the output gives the result of Kruskal-Wallis H test. Kruskal-Wallis H statistic (Chi-Square) is equal to 67.252 with significance (P-value) equal to 0.000. Thus, we conclude that AIDS rate is statistically significantly different between the six WHO regions.

Test Statistics[a,b]

	Cases per 100,000 population, 1993
Chi-Square	67.252
df	5
Asymp. Sig.	.000

[a.] Kruskal Wallis Test

[b.] Grouping Variable: WHO Region

Figure 5.25: Result of Kruskal-Wallis H Test

5.6   The Friedman Test: Three or More Dependent Samples

The Friedman test is used when you have one independent variable with three or more levels and an ordinal dependent variable. In other words, it is the non-parametric version of one-factor repeated measures ANOVA described in Chapter 4. We use Friedman test when the independent samples come from populations with the same shape, although not necessarily normal. The Friedman test can be used with ordinal, interval, or ratio data. It is often used when the assumptions of the one-factor repeated measures ANOVA have been violated.

Example 5.9:

Recall the SPSS data file **Blood_pressure.** Does systolic blood pressure change significantly during the three tasks examined in this study? The three tasks were: at rest [sbprest], performing mental arithmetic [sbpma], and immersing a hand in ice water [sbpcp].

SPSS Step by Step:

- Open the SPSS data file called **Blood_pressure**.

- Click on **Analyze⇒ Nonparametric Tests⇒ K dependent Samples…** The Tests for Several Related Samples dialog box will appear.
- Click [**sbprest**], [**sbpma**], and [**sbpcp**] and transfer them to Test Variable(s).
- There are several types of tests to choose from in the dialog box but we will agree with the default test, the **Friedman test**. The Tests for Several Related Samples dialog box will now look like Figure 5.26.
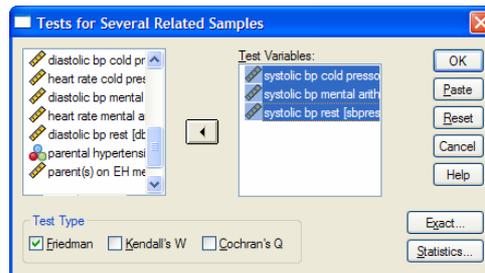

Figure 5.26: Tests for Several Related Samples

- Click on **<OK>** button in the dialog box to perform the Friedman test. The results have two main parts: Ranks statistics and inferential statistics.

Conclusion:

The first part, (shown in Figure 5.27), gives the mean ranks during the three tasks examined in this study. The mean ranks for the systolic blood pressure during immersing a hand in ice water, performing a mental arithmetic, and at rest are equal to 2.51, 2.28, and 1.21, respectively. These ranking appear quite different but we still have to rely on the statistical test to determine whether this sense is correct.

Ranks

	Mean Rank
systolic bp cold pressor	2.51
systolic bp mental arithmetic	2.28
systolic bp rest	1.21

Figure 5.27: Summary Statistics for Mean Ranks

The second part, (shown in Figure 5.28) of the output gives the result of Friedman test. Friedman statistic (Chi-Square) is equal to 170.411 with significance (P-value) equal to 0.000. Thus, we conclude that the systolic blood pressure changes significantly during the several physical and mental stressor tasks.

Test Statistics [a]

N	176
Chi-Square	170.411
df	2
Asymp. Sig.	.000

a. Friedman Test

Figure 5.28: Result of Friedman Test