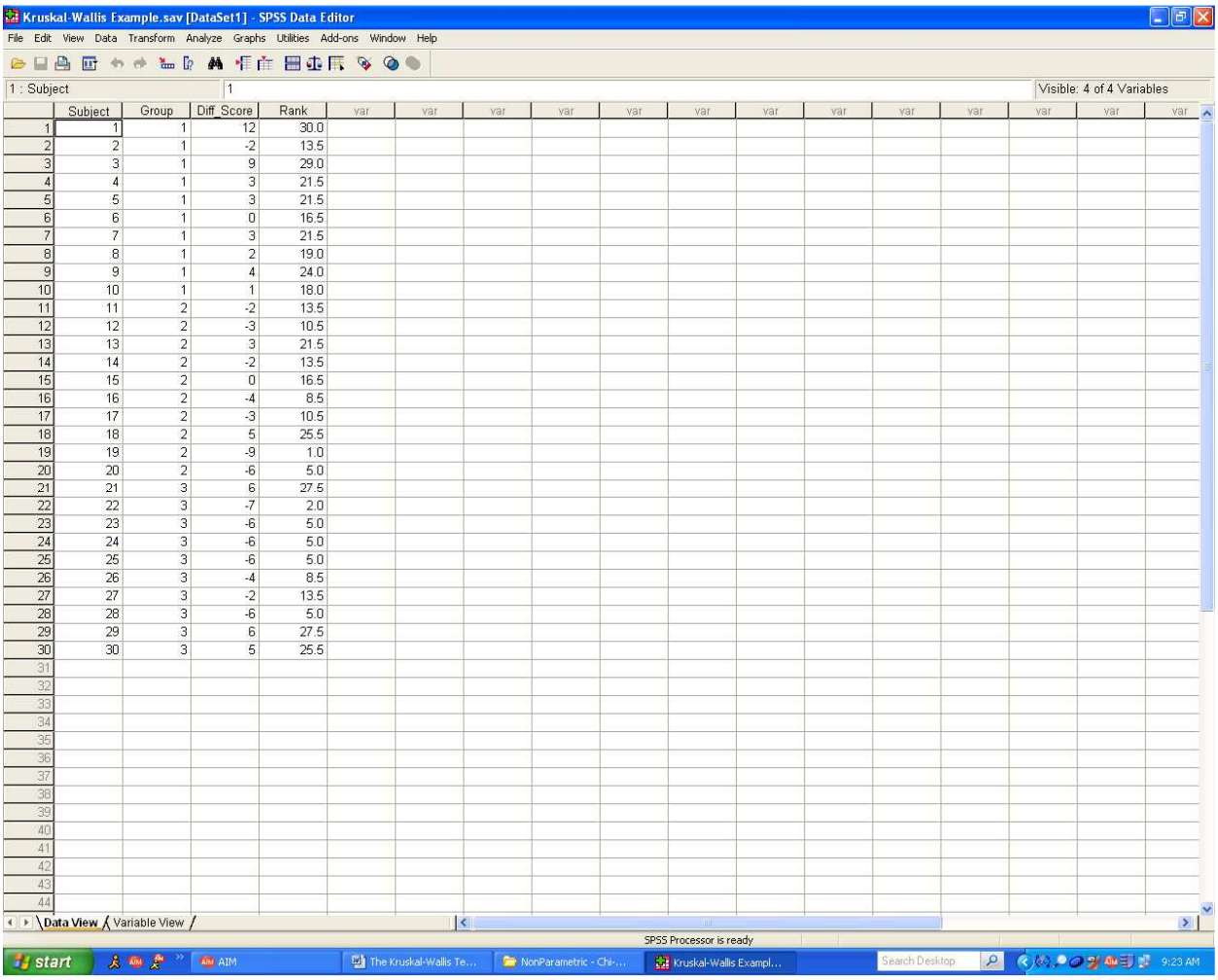
EPS 625 – INTERMEDIATE STATISTICS
KRUSKAL-WALLIS TEST

The Kruskal-Wallis test evaluates whether the population medians on a dependent variable are the same across all levels of a factor. To conduct the Kruskal-Wallis test, using the *K* independent samples procedure, cases must have scores on an independent or grouping variable and on a dependent variable. The independent or grouping variable divides individuals into two or more groups, and the dependent variable assesses individuals on at least an ordinal scale.

If the independent variable has only two levels, no additional significance tests need to be conducted beyond the Kruskal-Wallis test. However, if a factor has more than two levels and the overall test is significant, follow-up tests are usually conducted. These follow-up tests most frequently involve comparisons between pairs of group medians. For the Kruskal-Wallis, we could use the Mann-Whitney *U* test to examine unique pairs.

UNDERSTANDING THE KRUSKAL-WALLIS TEST

To help understand how the Kruskal-Wallis test evaluates differences in medians among groups, we will look at an example provided by Green and Salkind (2008). First, we must describe what data are being analyzed in this test. We will be using an example dealing with Vitamin C to demonstrate the Kruskal-Wallis test (Lesson 43 from Green & Salkind).



	Subject	Group	Diff_Score	Rank
1	1	1	12	30.0
2	2	1	-2	13.5
3	3	1	9	29.0
4	4	1	3	21.5
5	5	1	3	21.5
6	6	1	0	16.5
7	7	1	3	21.5
8	8	1	2	19.0
9	9	1	4	24.0
10	10	1	1	18.0
11	11	2	-2	13.5
12	12	2	-3	10.5
13	13	2	3	21.5
14	14	2	-2	13.5
15	15	2	0	16.5
16	16	2	-4	8.5
17	17	2	-3	10.5
18	18	2	5	25.5
19	19	2	-9	1.0
20	20	2	-6	5.0
21	21	3	6	27.5
22	22	3	-7	2.0
23	23	3	-6	5.0
24	24	3	-6	5.0
25	25	3	-6	5.0
26	26	3	-4	8.5
27	27	3	-2	13.5
28	28	3	-6	5.0
29	29	3	6	27.5
30	30	3	5	25.5

The data set includes scores on the dependent variable (difference in number of colds from one year to the next) and their rank order, disregarding levels of the factor (Vitamin C group), from lowest to highest for the Kruskal-Wallis test. With the Kruskal-Wallis test, a chi-square statistic is used to evaluate differences in mean ranks to assess the null hypothesis that the medians are equal across the groups.

Assumptions Underlying a Mann-Whitney *U* Test

Because the analysis for the Kruskal-Wallis test is conducted on ranked scores, the population distributions for the test variable (the scores that the ranks are based on) do not have to be of any particular form (e.g., normal). However, these distributions should be continuous and have identical form.

Assumption 1: The continuous distributions for the test variable are exactly the same (except their medians) for the different populations.

Assumption 2: The cases represent random samples from the populations, and the scores on the test variable are independent of each other.

Assumption 3: The chi-square statistic for the Kruskal-Wallis test is only approximate and becomes more accurate with larger sample sizes.

> The *p* value for the chi-square approximation test is fairly accurate if the number of cases is greater than or equal to 30.

Effect Size Statistics for the Mann-Whitney *U* Test

SPSS does not report an effect size index for the Kruskal-Wallis test. However, simple indices can be computed to communicate the size of the effect.

For the Kruskal-Wallis test, the median and the mean rank for each of the groups can be reported. Another possibility for the Kruskal-Wallis test is to compute an index that is usually associated with a one-way ANOVA, such as eta square (η^2), except η^2 in this case would be computed on the ranked data. To do so, transform the scores to ranks, conduct an ANOVA, and compute an eta square on the ranked scores. Eta square can also be computed directly from the reported chi-square value for the Kruskal-Wallis test with the use of the following equation:

$$\eta^2 = \frac{\chi^2}{N-1}$$

> Where *N* is the total number of cases

The Data Set

The data set that we will look at for this example is from *Lesson 43* from Green and Salkind's (2008) *Using SPSS for Windows and Macintosh: Analyzing and Understanding Data (5th ed.).* The data set represents data from an example looking at Vitamin C.

The grouping variable (GROUP) has three levels: 1 = Placebo, 2 = Low Doses of Vitamin C, and 3 = High Doses of Vitamin C. The test variable (DIFF_SCORE) is the number of days in year 2 with cold symptoms minus the number of days in year 1 with cold symptoms.

THE RESEARCH QUESTIONS

The research questions used in this example can be asked to reflect differences in medians between groups or a relationship between two variables.

1. Differences between the medians: Do the medians for change in the number of days of cold symptoms differ among those who take a placebo, those who take low doses of vitamin C, and those who take high doses of vitamin C?
2. Relationship between two variables: Is there a relationship between the amount of vitamin C taken and the change in the number of days that individuals show cold symptoms?

CONDUCTING THE *K* INDEPENDENT-SAMPLES (KRUSKAL-WALLIS) TEST IN SPSS

To conduct the Kruskal-Walls test and follow-up tests using the Mann-Whitney *U* test in SPSS, use the following steps:

- Open the dataset in SPSS to be used for the Kruskal-Wallis Test analysis
- Click **Analyze**, click (mouse over) **Nonparametric Tests**, and then click **K Independent-Samples**
    - You should now be in the Test for Several Independent Samples dialog box
        - Click on your (*Test Variable*), and click ► to move it to the Test Variable List: box
        - Click on your (*Grouping Variable*), and click ► to move it to the Grouping Variable: box
        - Click **Define Range**
            - Type **1** as the Minimum value for Group
            - Type **3** (for this example) as the Maximum value for Group
                - The maximum value will be based on the specific scenario. For example, with four levels, you would type 4 for the maximum value.
            - Click **Continue**
        - Click **Options**
            - Under Statistics
                - Select [√] **Descriptive**
            - Click **Continue**
        - Be sure **Kruskal-Wallis H** is checked in the Test Type area.

- Click **OK**

- You are now ready to analyze the output data…

SPSS OUTPUT

NPar Tests

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum
Diff_Score	30	-.20	5.182	-9	12
Vitamin C Treatment	30	2.00	.830	1	3

Kruskal-Wallis Test

Ranks

	Vitamin C Treatment	N	Mean Rank
Diff_Score	Placebo	10	21.45
	Low Dose	10	12.60
	High Dose	10	12.45
	Total	30	

Test Statistics[a,b]

	Diff_Score
Chi-Square	6.923
df	2
Asymp. Sig.	.031

a. Kruskal Wallis Test

b. Grouping Variable: Vitamin C Treatment

The results of the analysis indicates that there is a significant difference in the medians, $\chi^2(2, N = 30) = 6.92$, $p = .03$. Because the overall test is significant, pairwise comparisons among the three groups should be completed.

CONDUCTING PAIRWISE COMPARISONS AFTER OBTAINING A SIGNIFICANT KRUSKAL-WALLIS TEST IN SPSS

The pariwise comparisons will be conducted using the Mann-Whitney *U* test, which yields identical results with the Kruskal-Wallis test for two independent samples. For each pairwise comparison, the values in the *Define Groups* dialog box will be changed to match the comparison of interest (e.g., 1 vs. 2, 1 vs. 3, etc.). Don't forget to protect for Type I Error, by adjusting the *a priori* alpha level divided by the number of comparisons (Bonferroni adjustment).

To conduct the Mann-Whitney *U* test in SPSS, use the following steps:

- Click **Analyze**, click (mouse over) **Nonparametric Tests**, and then click **2 Independent-Samples**
  - You should now be in the Two-Independent Samples Tests dialog box
    - Click on your (*Test Variable*), and click ► to move it to the Test Variable List: box
    - Click on your (*Grouping Variable*), and click ► to move it to the Grouping Variable: box
    - Click **Define Groups**
      - Type **1** in the Group 1 box to indicate that Group 1 is the first level of your grouping variable.
      - Type **2** in the Group 2 box indicating that Group 2 is the second level of your grouping variable.
      - Click **Continue**
    - Click **Options**
      - Under Statistics
        - Select [√] **Descriptive**
      - Click **Continue**
    - Be sure **Mann-Whitney U** is checked in the Test Type area.
    - Click **OK**
- You are now ready to analyze the output data…

To perform the subsequent comparisons, repeat the above steps, except indicate in the Define Groups dialog box the groups of interest. For this example, use Groups 1 and 3 for the second comparison and Groups 2 and 3 for the third comparison.

SPSS OUTPUT

Comparing Group 1 (Placebo) to Group 2 (Low Dose)

NPar Tests

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum
Diff_Score	30	-.20	5.182	-9	12
Vitamin C Treatment	30	2.00	.830	1	3

Mann-Whitney Test

Ranks

	Vitamin C Treatment	N	Mean Rank	Sum of Ranks
Diff_Score	Placebo	10	13.90	139.00
	Low Dose	10	7.10	71.00
	Total	20		

Test Statistics[b]

	Diff_Score
Mann-Whitney U	16.000
Wilcoxon W	71.000
Z	-2.586
Asymp. Sig. (2-tailed)	.010
Exact Sig. [2*(1-tailed Sig.)]	.009[a]

a. Not corrected for ties.

b. Grouping Variable: Vitamin C Treatment

Comparing Group 1 (Placebo) to Group 3 (High Dose)

NPar Tests

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum
Diff_Score	30	-.20	5.182	-9	12
Vitamin C Treatment	30	2.00	.830	1	3

Mann-Whitney Test

Ranks

	Vitamin C Treatment	N	Mean Rank	Sum of Ranks
Diff_Score	Placebo	10	13.05	130.50
	High Dose	10	7.95	79.50
	Total	20		

Test Statistics[b]

	Diff_Score
Mann-Whitney U	24.500
Wilcoxon W	79.500
Z	-1.939
Asymp. Sig. (2-tailed)	.052
Exact Sig. [2*(1-tailed Sig.)]	.052[a]

a. Not corrected for ties.

b. Grouping Variable: Vitamin C Treatment

Comparing Group 2 (Low Dose) to Group 3 (High Dose)

NPar Tests

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum
Diff_Score	30	-.20	5.182	-9	12
Vitamin C Treatment	30	2.00	.830	1	3

Mann-Whitney Test

Ranks

	Vitamin C Treatment	N	Mean Rank	Sum of Ranks
Diff_Score	Low Dose	10	11.00	110.00
	High Dose	10	10.00	100.00
	Total	20		

Test Statistics[b]

	Diff_Score
Mann-Whitney U	45.000
Wilcoxon W	100.000
Z	-.382
Asymp. Sig. (2-tailed)	.702
Exact Sig. [2*(1-tailed Sig.)]	.739[a]

a. Not corrected for ties.

b. Grouping Variable: Vitamin C Treatment

APA RESULTS

Based on the results produced from the above example, the APA results would be:

A Kruskal-Wallis test was conducted to evaluate differences among the three vitamin C conditions (Placebo, Low Dose of Vitamin C, and High Dose of Vitamin C) on median change in number of days with cold symptoms (number of days with colds during treatment minus number of days with colds prior to treatment). The test, which was corrected for tied ranks, was significant $\chi^2(2, N = 30) = 6.92, p = .03$. The proportion of variability in the ranked dependent variable accounted for by the vitamin C treatment variable was .24, indicating a fairly strong relationship between vitamin C treatment and the change in the number of days with colds.

Follow-up tests were conducted to evaluate pairwise differences among the three groups, controlling for Type I error across tests by using the Bonferroni approach. The results of these tests indicated a significant difference between the placebo group and the low-dose vitamin C group. The typical decrease in number of days with cold symptoms after treatment was greater for the low-dose vitamin C treatment group than for the placebo group.

*The following Case Summaries Table may be needed to better understand the above results…

Case Summaries

Diff_Score

Vitamin C Treatment	N	Mean
Placebo	10	3.50
Low Dose	10	-2.10
High Dose	10	-2.00
Total	30	-.20

REFERENCE

Green, S. B., & Salkind, N. J. (2008). *Using SPSS for Window and Macintosh: Analyzing and understanding data* (5th ed.). Upper Saddle River, NJ: Pearson Prentice Hall.