STATS 10x Workshop

Hypothesis Tests in SPSS [HTS]

2017

by Leila Boyle

STATS 10x Workshops

The Statistics Department offers workshops and one-to-one/small group assistance for STATS 10x students wanting to improve their statistics skills and understanding of core concepts and topics.

Leila's website for STATS 10x workshop hand-outs and information is here: **www.tinyURL.com/stats-10x**

Resources for this workshop, including pdfs of this hand-out, the answers and data files are available here: **www.tinyURL.com/stats-HTS**

Want to get in touch with Leila?
l.boyle@auckland.ac.nz; (09) 923-9045; 021 447-018
Room 303.320 (third floor of the Science Centre)

Register your interest in this semester's workshops here:
www.tinyURL.com/stats-EOI

Please log in and go to www.tinyURL.com/stats-HTS

Table of Contents

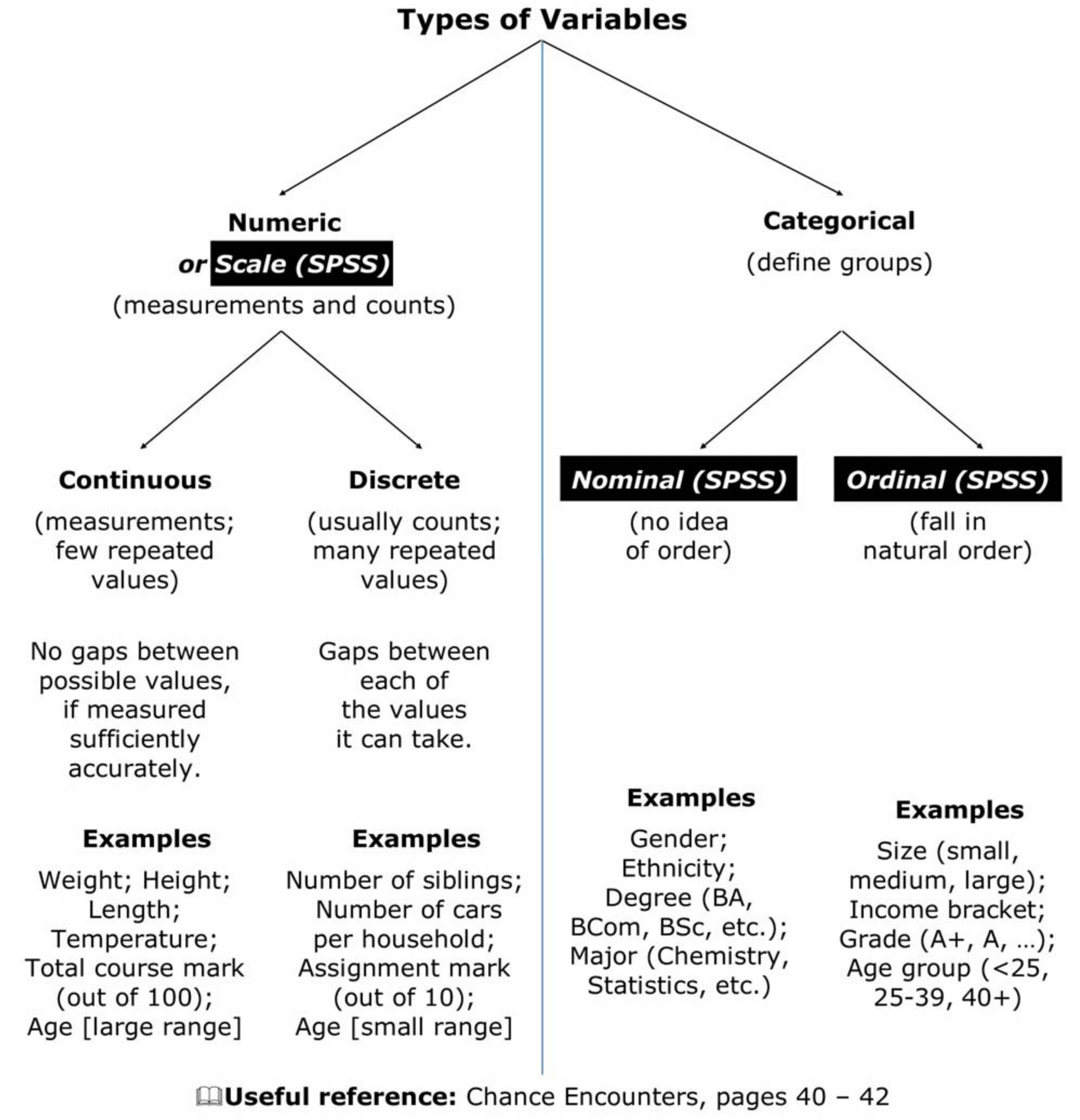
Introduction

Generally our approach to our data should be:

plot $\rightarrow$ look $\rightarrow$ formal analyses $\rightarrow$ conclusion

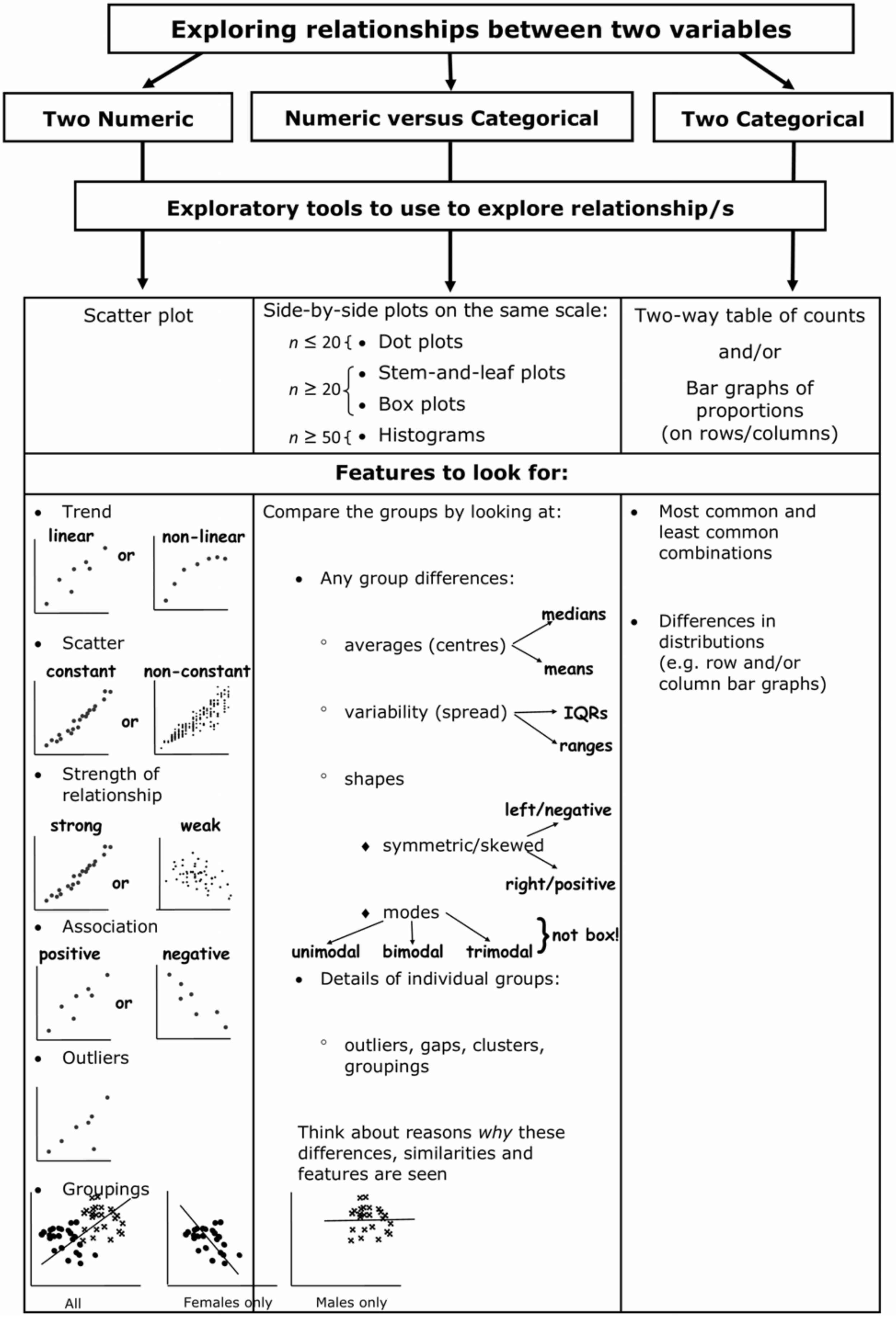
Types of variables

Before we get into plotting our data (prior to doing our formal statistical analyses like hypothesis tests and confidence intervals), we need to begin by identifying what types of variables our dataset contains:



Exploring relationships between two variables

The relationships between types of variables can be explored as follows:


Exploring relationships between two variables
Two Numeric
Numeric versus Categorical
Two Categorical
Exploratory tools to use to explore relationship/s
Scatter plot
Side-by-side plots on the same scale:
n ≤ 20 { • Dot plots
n ≥ 20 { • Stem-and-leaf plots
• Box plots
n ≥ 50 { • Histograms
Two-way table of counts
and/or
Bar graphs of proportions (on rows/columns)
Features to look for:
• Trend
linear
or
non-linear
• Scatter
constant
or
non-constant
• Strength of relationship
strong
or
weak
• Association
positive
or
negative
• Outliers
• Groupings
All
Females only
Males only
Compare the groups by looking at:
• Any group differences:
◦ averages (centres)
medians
means
◦ variability (spread)
IQRs
ranges
◦ shapes
♦ symmetric/skewed
left/negative
right/positive
♦ modes
unimodal
bimodal
trimodal
} not box!
• Details of individual groups:
◦ outliers, gaps, clusters, groupings
Think about reasons *why* these differences, similarities and features are seen
• Most common and least common combinations
• Differences in distributions (e.g. row and/or column bar graphs)

Now that we have **explored, displayed and described our sample data**, (***Basic Data Analysis*** workshop – **www.tinyurl.com/stats-BDA**), we need to carry out appropriate statistical analyses (hypothesis tests) to determine if there is a (statistically significant) effect or difference present. We also should construct confidence intervals to quantify the size of the effect or difference.

Today we will use SPSS to do the appropriate hypothesis tests and confidence intervals for us. If you want to learn more about the theory and interpretation of these, see the ***Hypothesis Tests: Means*** workshop, (**www.tinyURL.com/stats-HTM**) which covers four scenarios:

- ***A single mean***
- ***Paired data***
- ***Differences between two means***
- ***Differences between three or more means***

The ***Confidence Intervals: Means*** (**www.tinyURL.com/stats-CIM**) workshop material also covers **how we quantify the size of a single mean or difference between two means** if you want more practice.

All parametric hypothesis tests have a normality assumption, which we need to check before we interpret the results of the test.

Hypothesis tests: Non-parametric tests

✓ Used when there are strong concerns about the "normality" of the data. You should make sure data don't show separation into clusters or have a multi-modal nature (i.e. the data is unimodal) and then apply the 15-40 guide as follows:

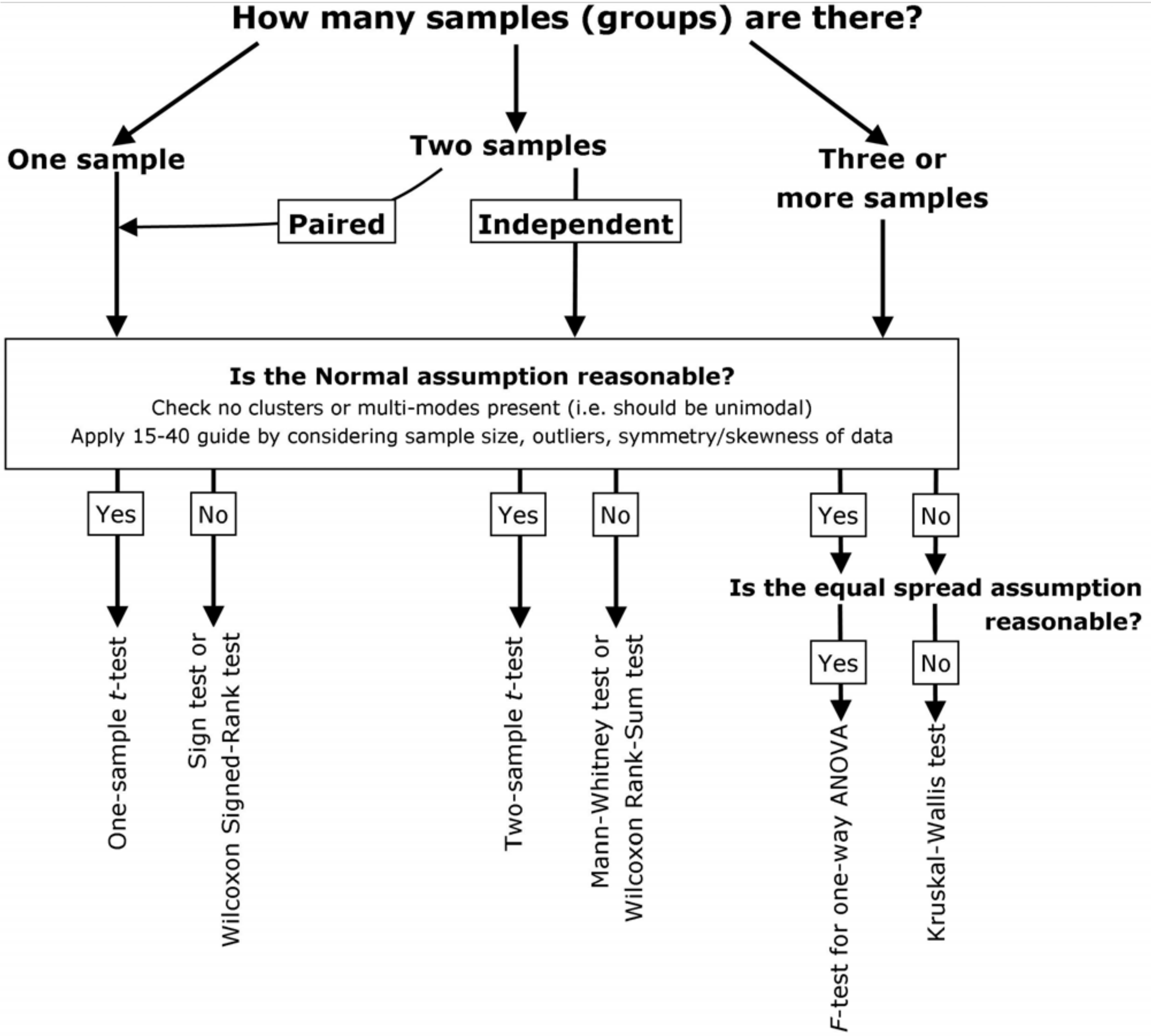
Sample Size Guidelines – "15 – 40 Guide"

Small (total $n \leq 15$ or so)	Medium ($15 <$ total $n < 40$)	Large (total $n \geq 40$ or so)
no outliers	no outliers	no gross outliers
at most, slight skewness	not strongly skewed	data may be strongly skewed

✓ They test the **median(s)**, $\tilde{\mu}$, NOT the mean(s), μ.

Which hypothesis test/s should I use?

The following diagram can help you decide which hypothesis test/s you can use:



Assumptions	Checks
1. Independence — All tests - Single sample assumes indep. between observations. - Paired data assumes indep. between pairs of observations. - Two or more samples assumes indep. between observations and samples.	- The design of the experiment/study
2. Normality — Parametric tests only - one-sample *t*-test - two-sample *t*-test - *F*-test for one-way ANOVA	- Plot the data - Apply 15-40 guide
3. Equal spread — *F*-test for one-way ANOVA only	- Plot the data - Check the standard deviation ratio: $\frac{\text{largest sd}}{\text{smallest sd}} < 2$

Hypothesis tests: *P-values*

All hypothesis tests include a *P*-value, which we use to interpret the result, or outcome, of the test.

- The ***P*-value** measures the strength of evidence against the null hypothesis, H_0. The smaller the *P-value*, the stronger the evidence against H_0.

- There are two ways of interpreting the *P-value*:

1. As a description of the strength of evidence against H_0:

P-value	Evidence against H_0
> 0.10	None
≈ 0.10	Weak
≈ 0.05	Some
≈ 0.01	Strong
< 0.001	Very Strong

2. As a description of the test result as (statistically) significant or nonsignificant.

   A test result is significant when the *P-value* is "small enough"; usually we say a *P-value* is small enough if it is less than 0.05 (5%):

   Testing at a 5% level of significance:

P-value	Test result	Action
< 0.05	Significant	Reject H_0 in favour of H_1
> 0.05	Nonsignificant	Do not reject H_0

   Testing can be done at any level of significance; 1% is common but 5% what most researchers use.

   The level of significance is an error rate; and can be thought of as a *false alarm* rate: i.e. it is the proportion of the time that a true null hypothesis will be rejected.

To save you typing time, all of the data files required for this workshop can be found on Leila's website here: **www.tinyURL.com/stats-HTS**

Two Independent Samples – plotting the data and carrying out a two independent samples *t*-test for the *difference* between *two means*

Example: A random sample of 40 cellphones of the same make and model were chosen. Half of the cellphones were randomly selected to have a nickel-cadmium battery put in them and the rest had a nickel-metal hydride battery. The talk time (in minutes) before the batteries needed to be recharged was recorded. Carry out a two independent samples *t*-test for no difference in the means.

Two independent samples *t*-test

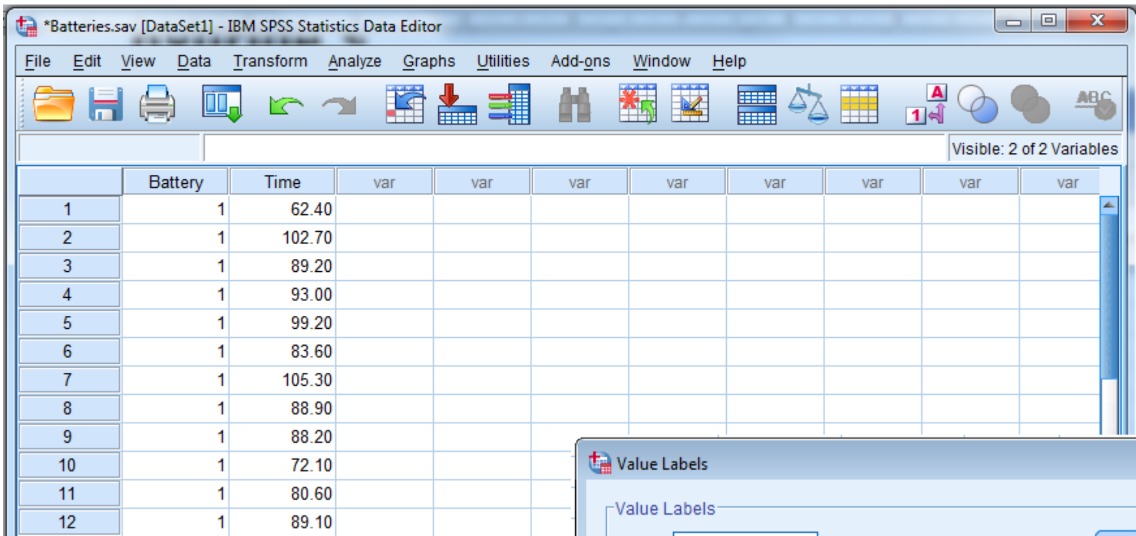
What are the correct null and alternative hypotheses for this test?

H_0:

vs H_1:

1. Open the Batteries.sav file from **www.tinyURL.com/stats-HTS**

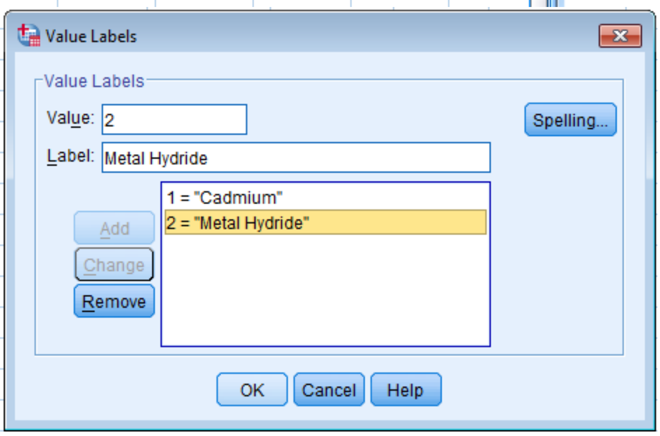
   Use a value of **1** for the nickel-cadmium battery type and **2** for the nickel-metal hydride battery type.



2. Assign labels.

   Label the values:

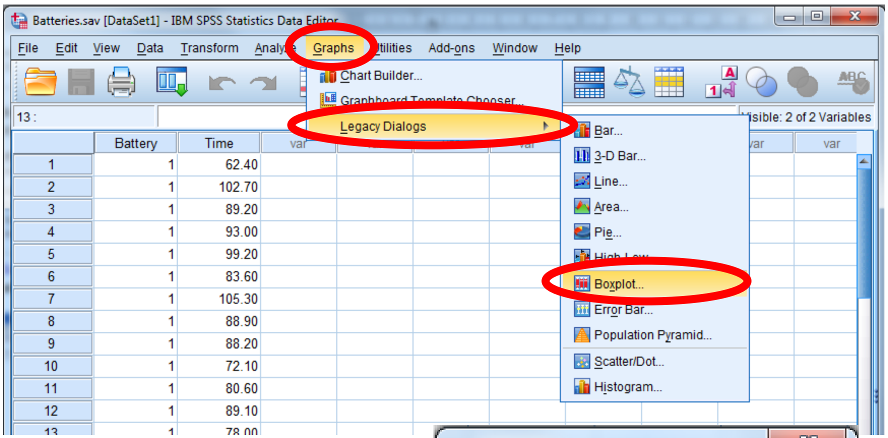
   Label **1** as **Cadmium** and **2** as **Metal Hydride**.



3. Plot the data using a boxplot.

   a. Choose the **Boxplot** tool:

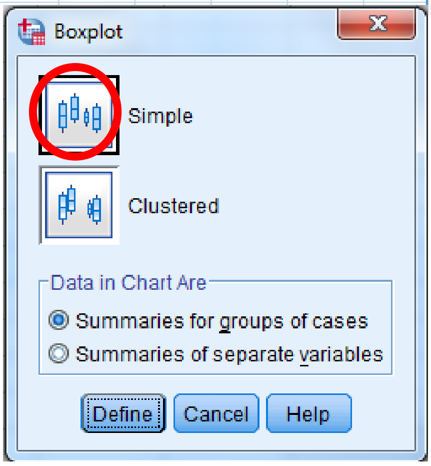
   Click **Graphs** → **Legacy Dialogs** → **Boxplot**



   b. Choose the type of boxplot.

   Simple is selected by default.

   Click **Define**.



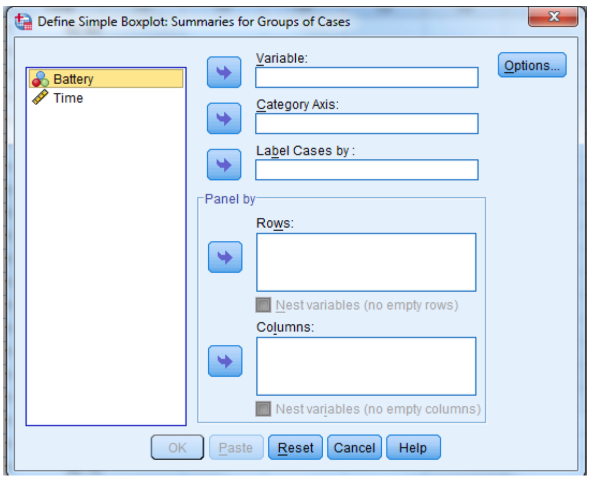
   c. Assign the variables.

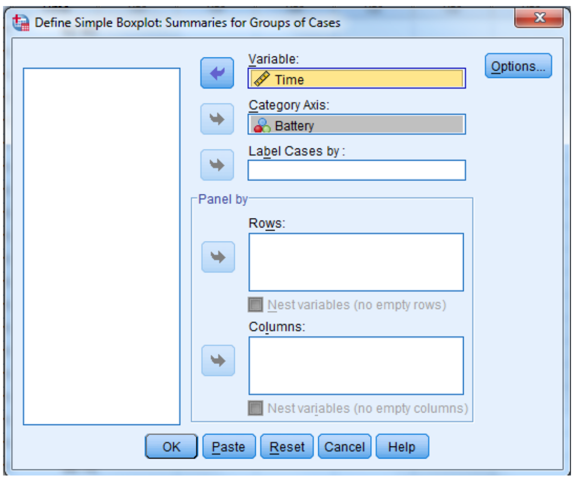
   Numeric (response) variable → **Variable** box.

   Click **Time**.
   Click

   Categorical variable (grouping factor) → **Category Axis** box.

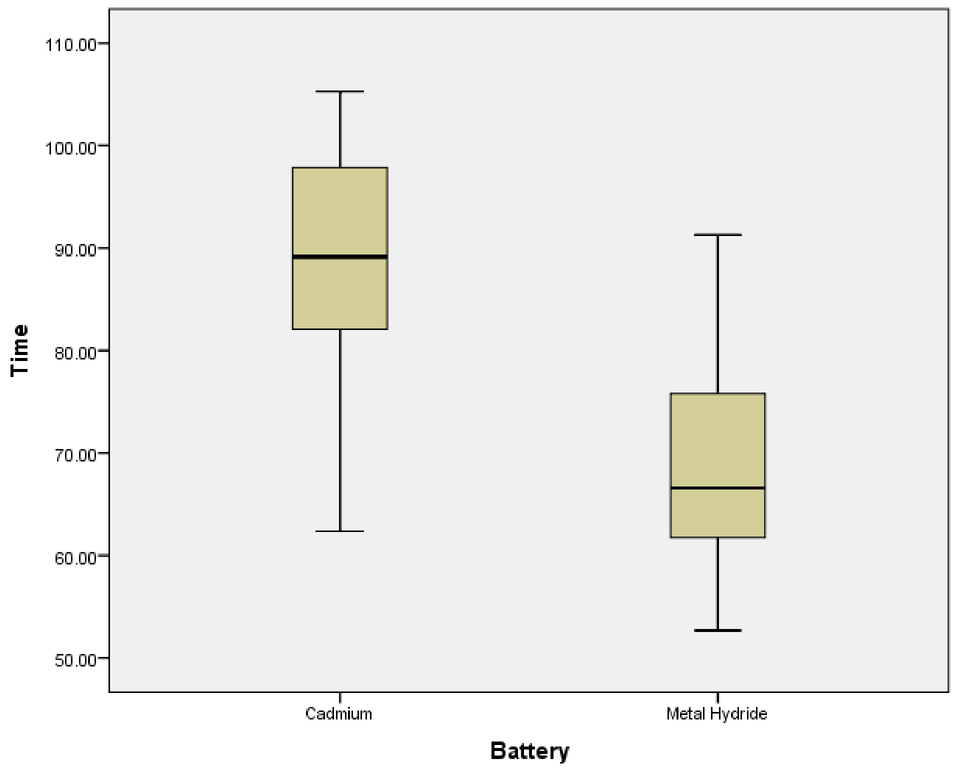
   Click **Battery**.
   Click





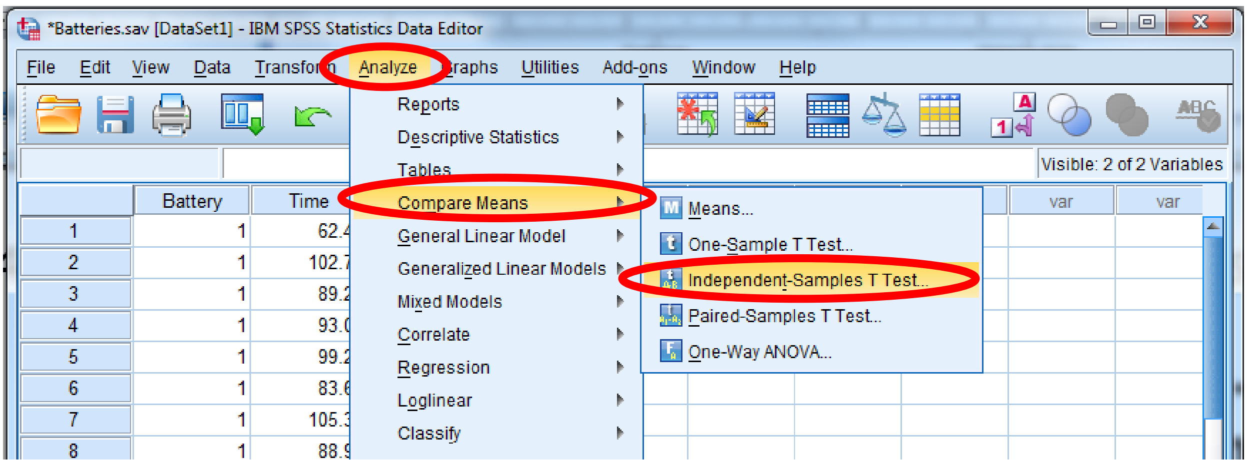
d. Click **OK**. The boxplots will appear in the **Output** window.

Time



4. Carry out the two independent sample *t*-test.

a. Choose the analysis tool: **Independent-Samples T Test**.
Click **Analyze** → **Compare Means** → **Independent-Samples T Test…**



b. Assign the variables of interest.

Numeric variable (response) → **Test Variable(s)** box.

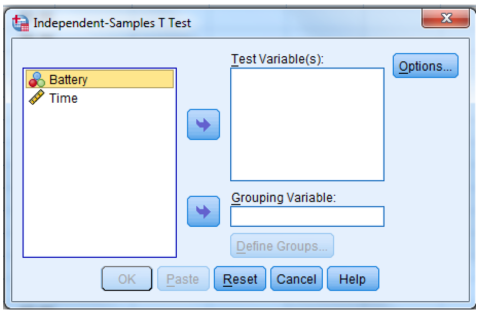
Click **Time**.

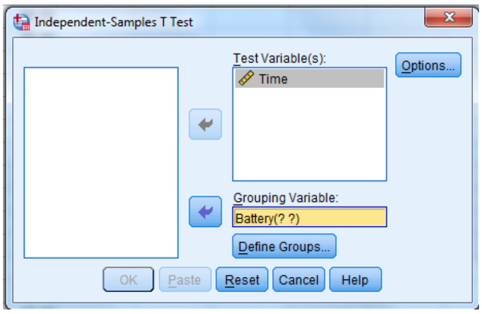
Click top .

Categorical variable (grouping factor) → **Grouping Variable** box.

Click **Battery**.

Click bottom .



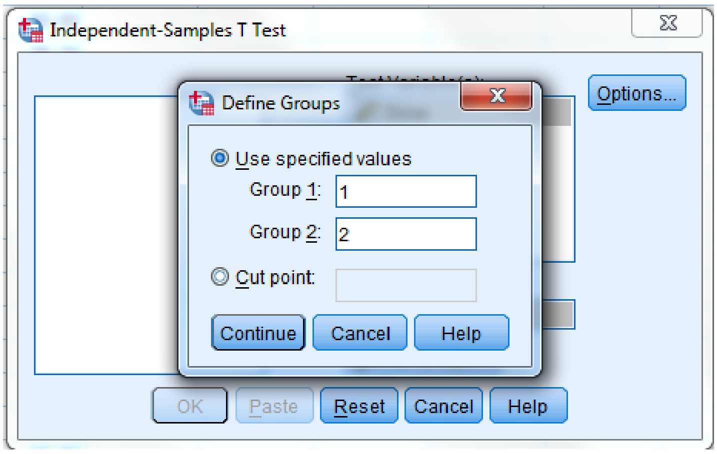


c. Define the direction of the difference (mean 1 – mean 2 or mean 2 – mean 1).

Click **Define Groups**.

Type **1** in the **Group 1** box and type **2** in the **Group 2** box.

Click **Continue** and then **OK**.



d. View and interpret the results.

T-Test

Group Statistics

	Battery	N	Mean	Std. Deviation	Std. Error Mean
Time	Cadmium	20	88.7050	11.76066	2.62976
	Metal Hydride	20	69.1900	10.30528	2.30433

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
Time	Equal variances assumed	.079	.780	5.581	38	.000	19.51500	3.49651	12.43668	26.59332
	Equal variances not assumed			5.581	37.356	.000	19.51500	3.49651	12.43267	26.59733

Paired Data Comparisons – finding the differences, plotting the data and carrying out a paired *t*-test for the *mean difference*

Example: A market research company is interested in which of two similar electric shavers, model A or model B, is preferred by consumers. 26 men who daily use an electric shaver, but not one of the models of interest are randomly selected to participate in the study. Half the men were randomly allocated to use model A one morning followed by model B the next morning whilst the order was reversed for the remaining men. After every shave, each man completed a questionnaire rating his satisfaction with the shaver. Satisfaction was measured as a score based on the answers to the questionnaire and is given in a range from 1 to 100. (Larger scores indicate greater satisfaction.)

Paired *t*-test

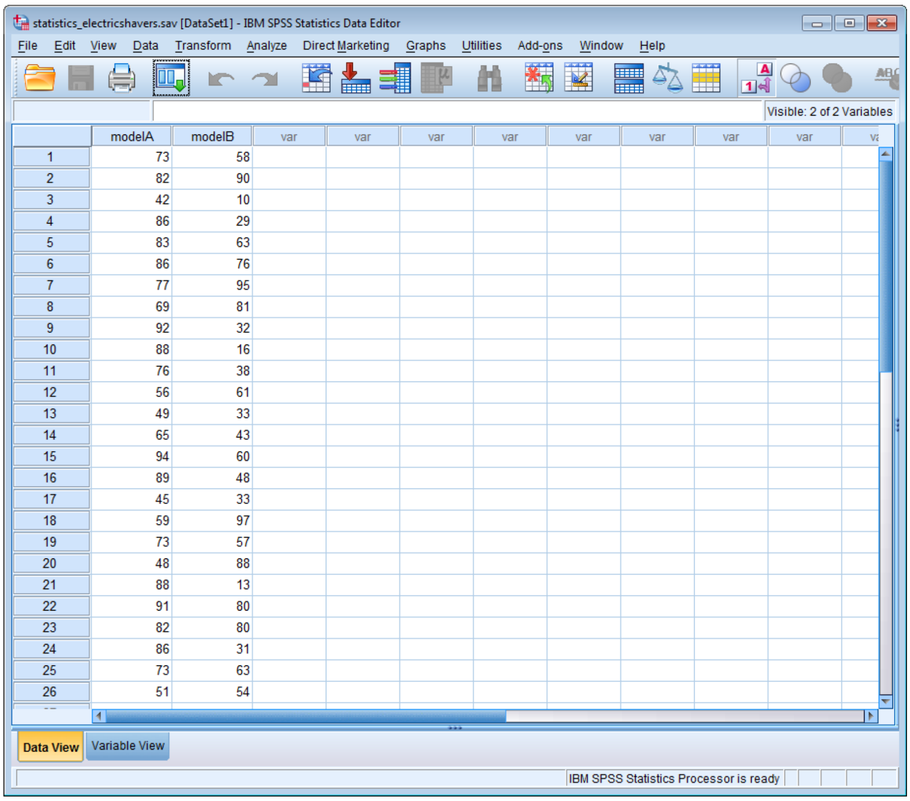
Carry out a paired data *t*-test for a mean difference of 0.

What are the correct null and alternative hypotheses for this test?

***H_0*:**

vs *H_1*:

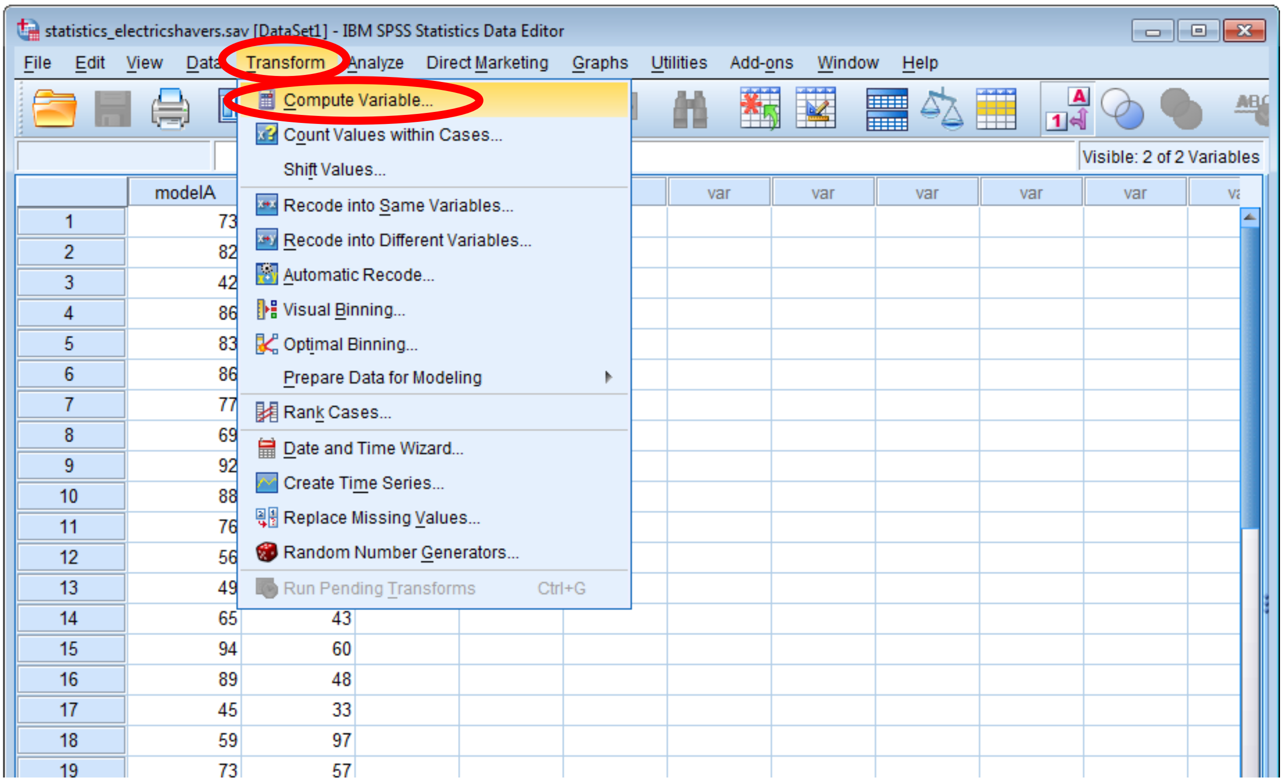
1. Enter the data into SPSS or open the ElectricShavers.sav file from **www.tinyURL.com/stats-HTS**



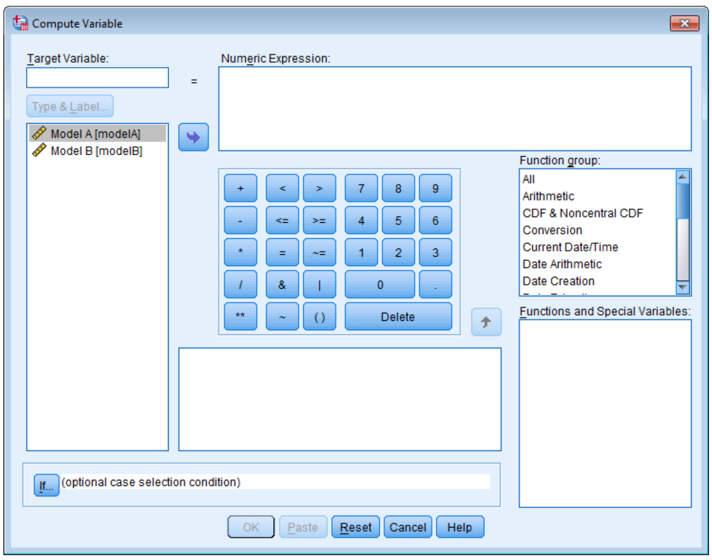
	modelA	modelB
1	73	58
2	82	90
3	42	10
4	86	29
5	83	63
6	86	76
7	77	95
8	69	81
9	92	32
10	88	16
11	76	38
12	56	61
13	49	33
14	65	43
15	94	60
16	89	48
17	45	33
18	59	97
19	73	57
20	48	88
21	88	13
22	91	80
23	82	80
24	86	31
25	73	63
26	51	54

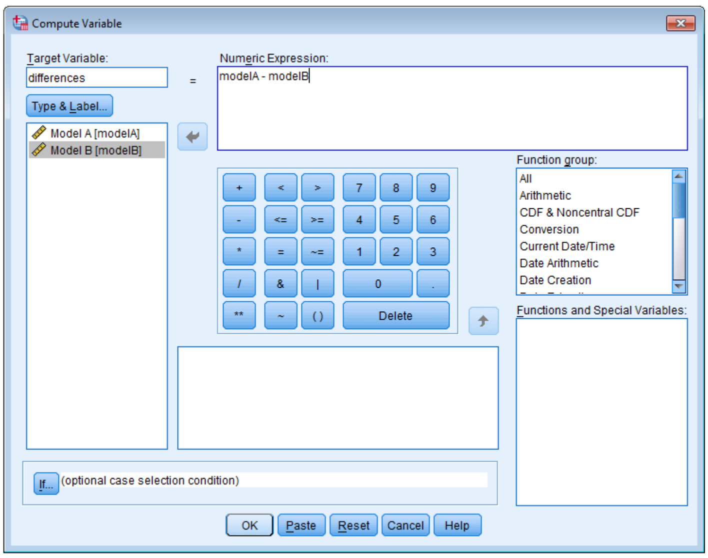
2. Find the differences:

   a. Choose the **Compute Variable** tool:
   Click **Transform → Compute Variable**

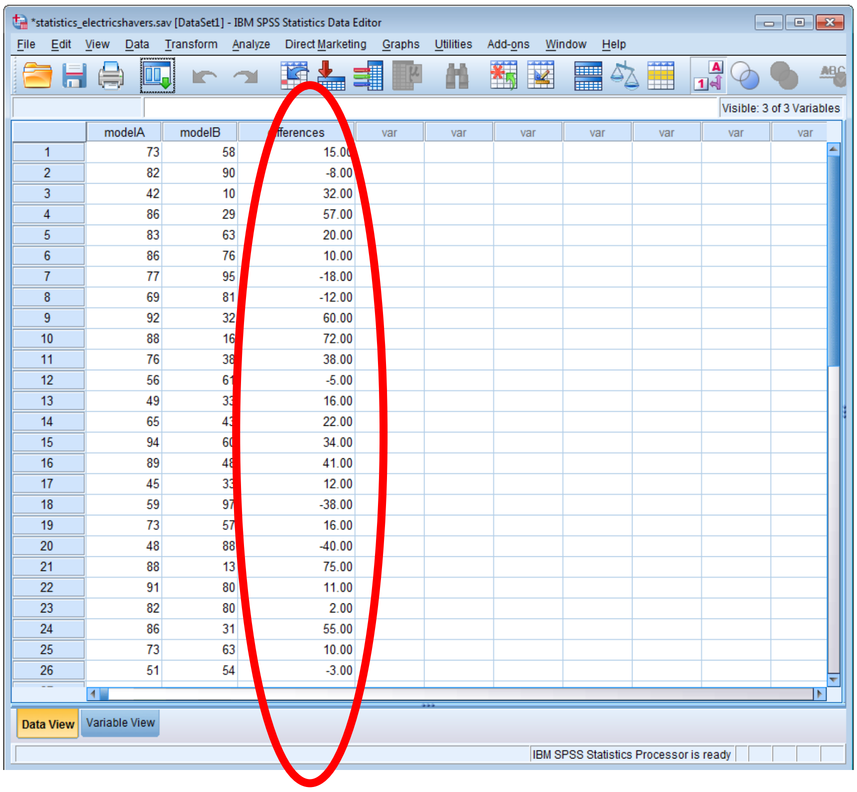


   b. Use the **Compute Variable** tool to find the differences:
   Type "differences" into the **Target Variable** field.
   Click **ModelA** then click
   Click (the subtraction button)
   Click **ModelB** then click
   Click **OK**



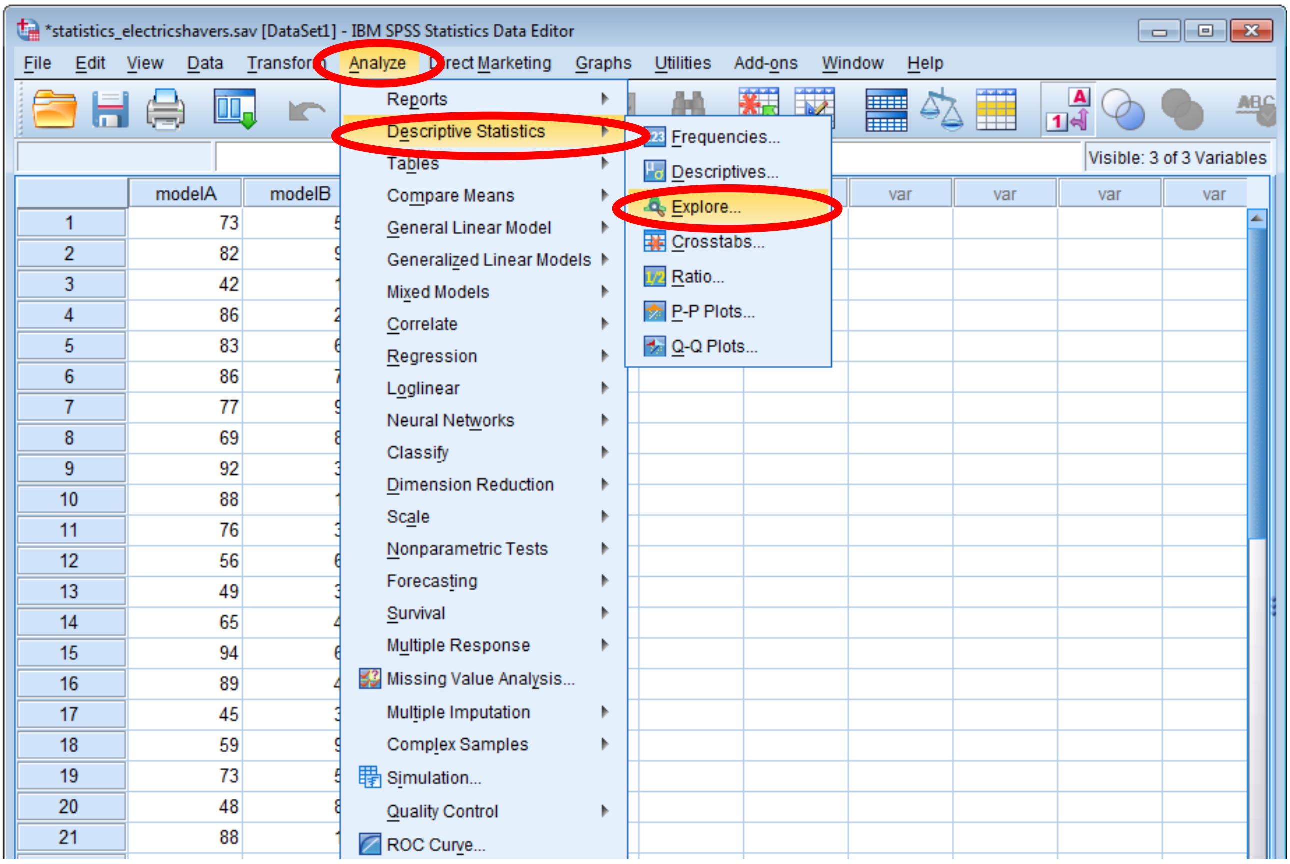


c. The differences will be computed and displayed in the **Data Editor**.

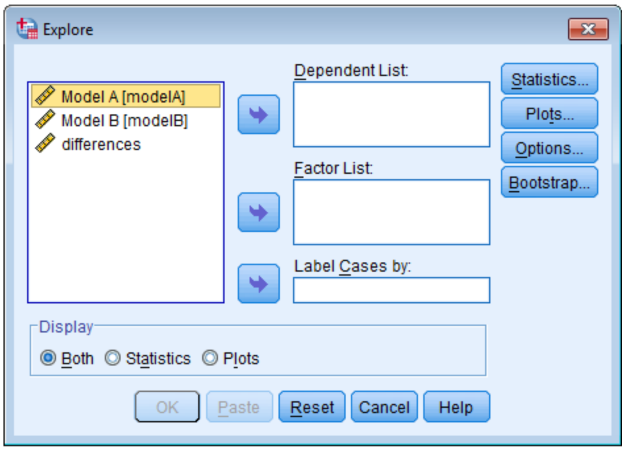


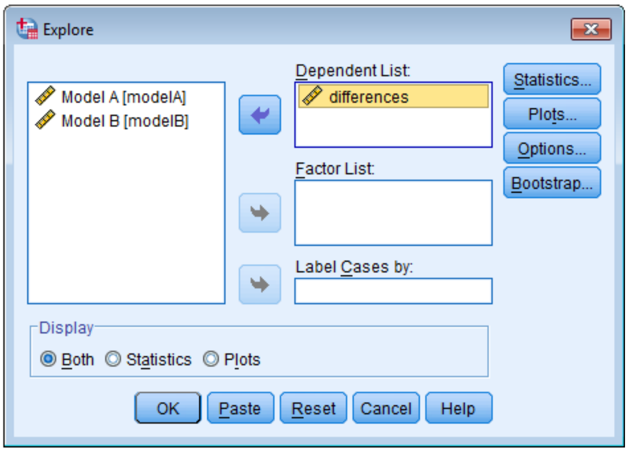
3. Plot the differences using a boxplot (sample size, $n = 26$).

a. Click **Analyze** → **Descriptive Statistics** → **Explore**

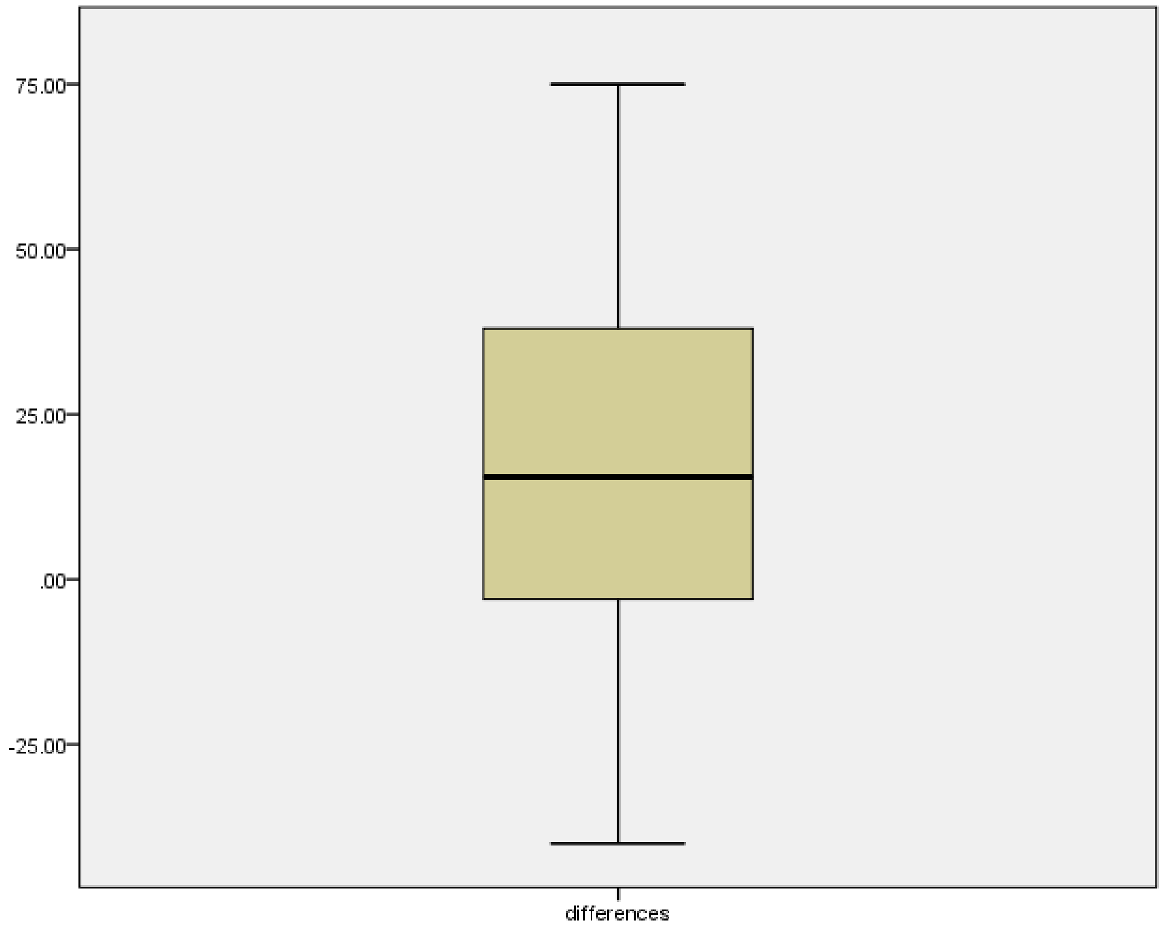


b. Assign the variable
Numeric (response) variable → **Dependent List** box.
Click **differences** then click top 



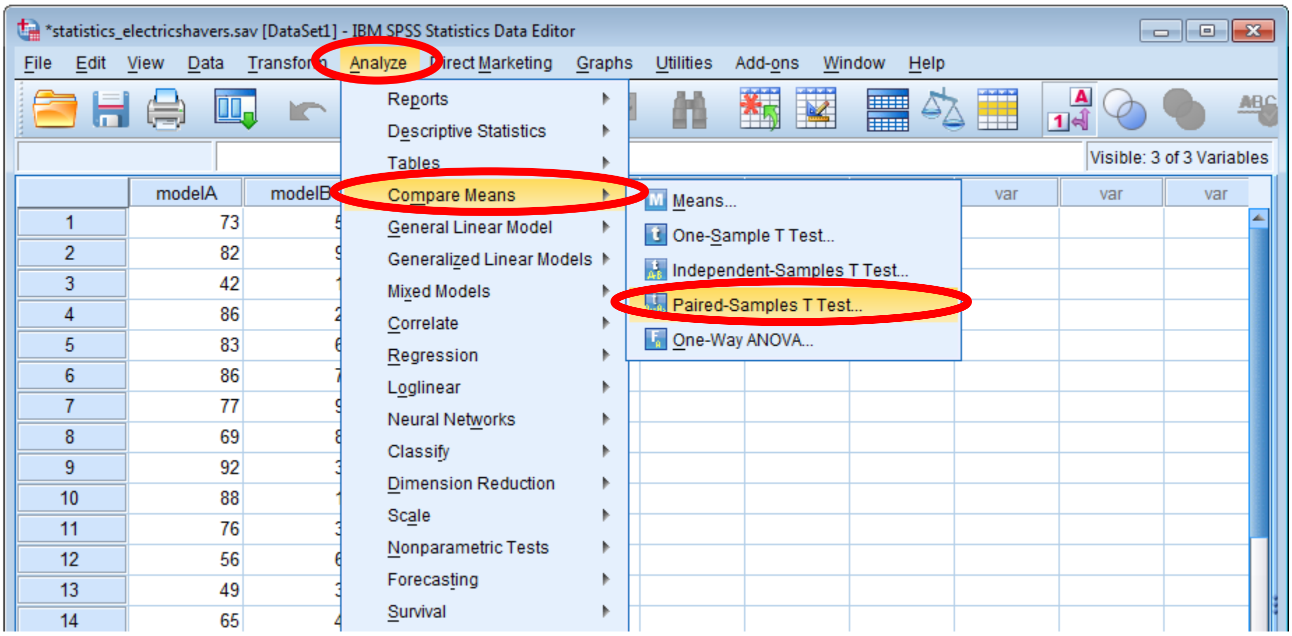


c. Click **OK**. The boxplot will appear in the **Output** window.

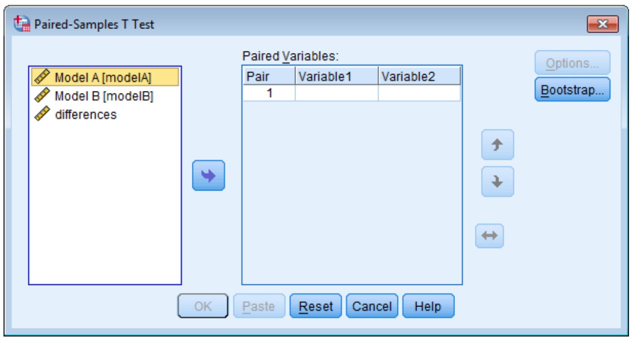


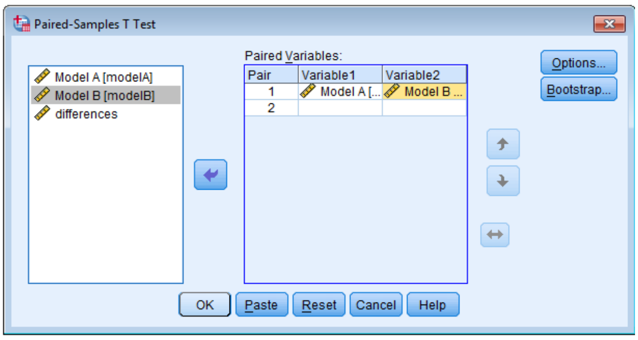
4. Carry out the paired *t*-test.

   a. Choose the analysis tool: **Paired-Samples T Test**.
   Click **Analyze** → **Compare Means** → **Paired-Samples T Test**.



   b. Select the variables of interest.
   ModelA is highlighted. Click
   Click on **ModelB** then click
   Click **OK**





   c. View and interpret the results.

T-Test

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Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference: Lower	95% Confidence Interval of the Difference: Upper			
Pair 1	Model A - Model B	18.231	30.362	5.955	5.967	30.494	3.062	25	.005

One Sample – plotting the data and carrying out a one sample *t*-test for the *mean*

One Sample *t*-test

Example: Of interest is whether the most recent road fatalities per capita per year for 26 countries has changed from the historical average of 15.5 per 100,000 inhabitants per year (for the same 26 countries in the mid-eighties). The data collected by the World Health Organization (WHO) is below. Carry out an appropriate one-sample *t*-test.

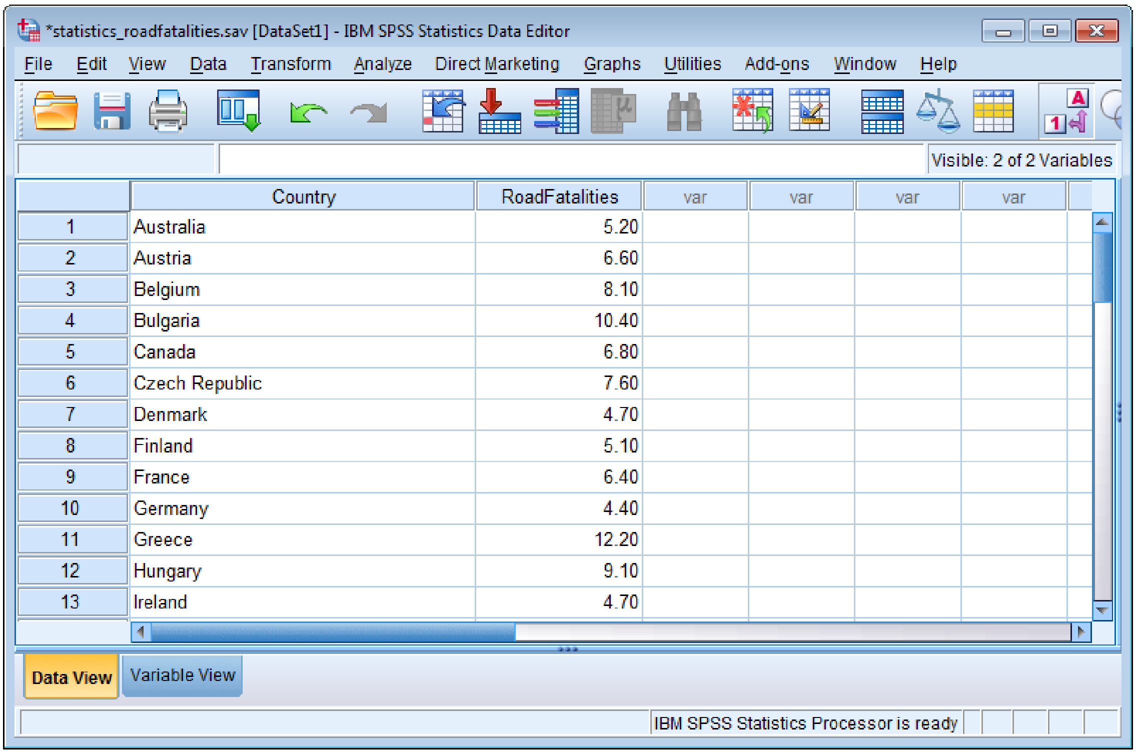
What are the correct null and alternative hypotheses for this test?

H_0:

vs H_1:

1. Enter the data into SPSS or download RoadFatalities.sav from **www.tinyURL.com/stats-HTS**

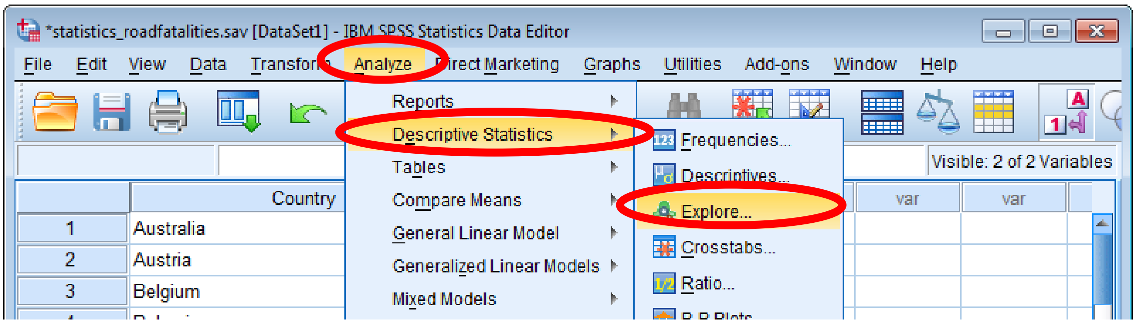
   Label **country** as **Country** and **RoadFatalities** as **Road fatalities per 100,000 inhabitants per year**.



	Country	RoadFatalities	var	var	var	var
1	Australia	5.20				
2	Austria	6.60				
3	Belgium	8.10				
4	Bulgaria	10.40				
5	Canada	6.80				
6	Czech Republic	7.60				
7	Denmark	4.70				
8	Finland	5.10				
9	France	6.40				
10	Germany	4.40				
11	Greece	12.20				
12	Hungary	9.10				
13	Ireland	4.70				

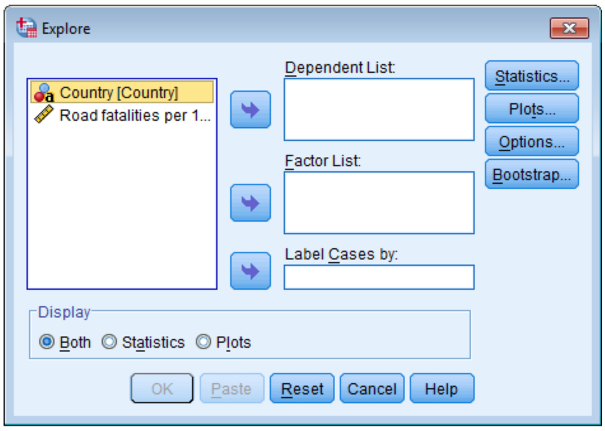
2. Plot the data using a boxplot (sample size, n = 26).

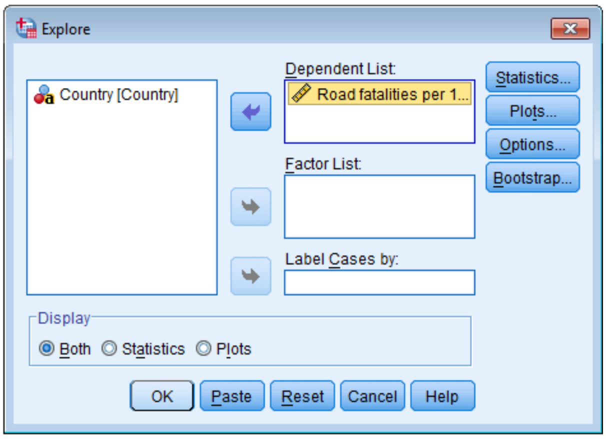
   a. Choose **Analyze** → **Descriptive Statistics** → **Explore**



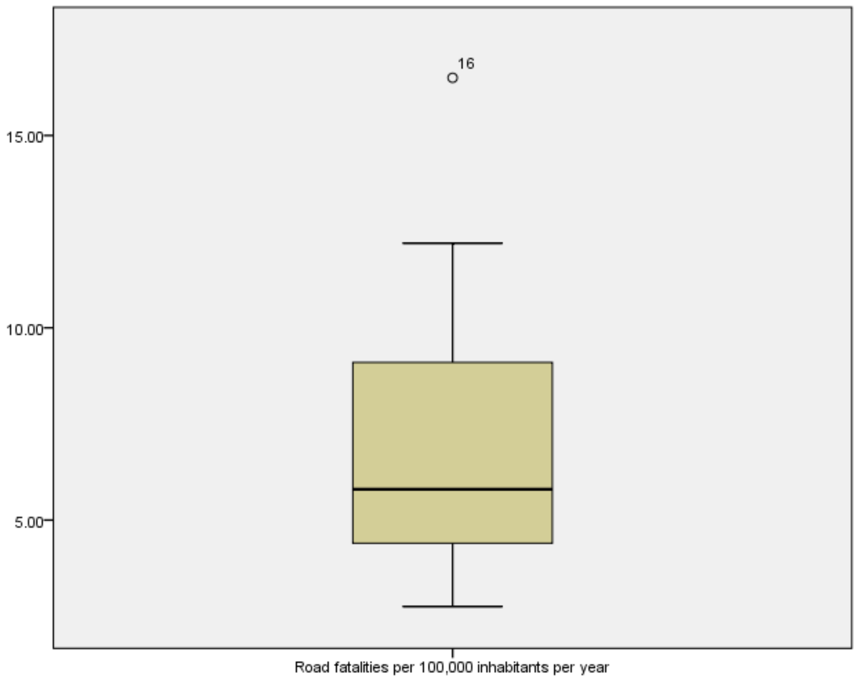
   b. Assign the variable.

   Numeric (response) variable → **Dependent List:** box
   Click **RoadFatalities** then click the top .



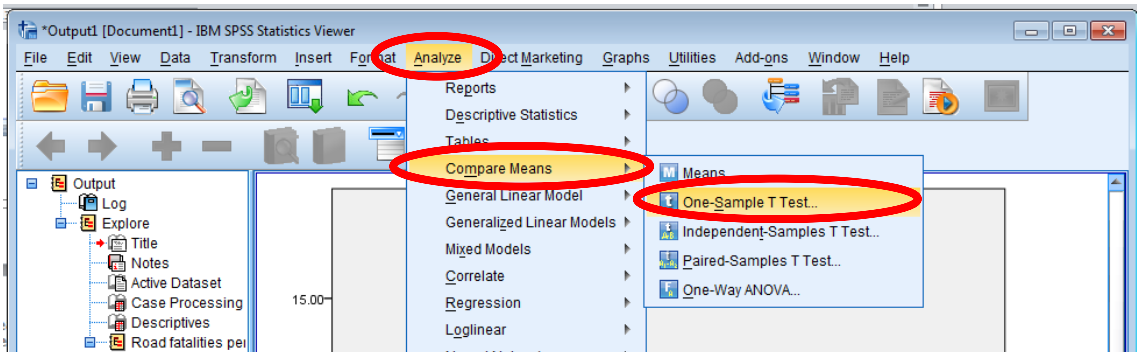


   c. Click **OK**. The boxplot will appear in the **Output** window.



3. Carry out the one sample *t*-test:

   a. Choose the analysis tool: **One-Sample T Test**
   Click **Analyze** → **Compare Means** → **One-Sample T Test**

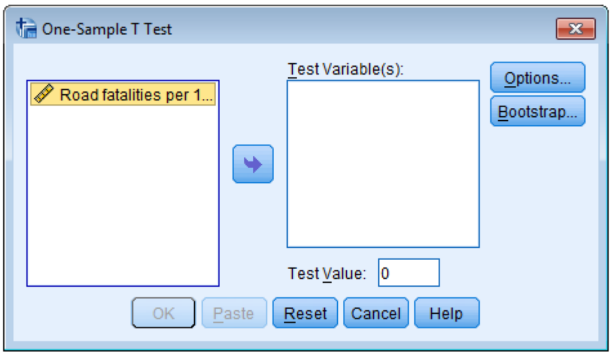


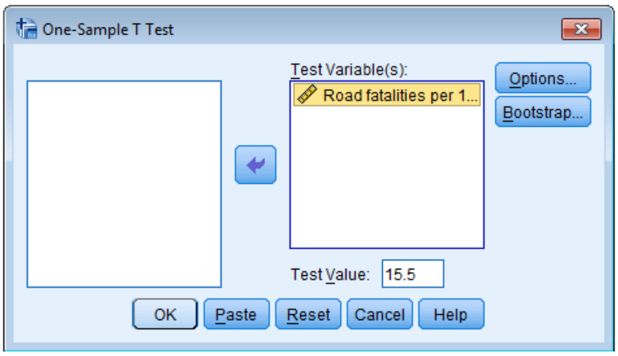
   b. Assign the variable:

      Numeric (response) variable → **Test Variable(s)** box.
      Click **RoadFatalities**, click

   Enter the appropriate hypothesised value:

      Enter 15.5 in the **Test Value:** field, click **OK**





   c. View and interpret the results.

T-Test

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
Road fatalities per 100,000 inhabitants per year	26	6.9019	3.34295	.65561

One-Sample Test

	Test Value = 15.5					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
Road fatalities per 100,000 inhabitants per year	-13.115	25	.000	-8.59808	-9.9483	-7.2478

Three or more samples – plotting the data and carrying out an *F*-test for one-way ANOVA for a *difference* between *three or more means*

Example: In 1989, 464 people were killed by a gun in the United States in a single week in May. These deaths have been grouped into four classes: **Accident**; **Homicide**; **Self defense**; and; **Suicide**. The age was also recorded for each person. Carry out a one-way ANOVA *F*-test for no difference in the groups' underlying means.

F-test for one-way ANOVA

What are the correct null and alternative hypotheses for this test?

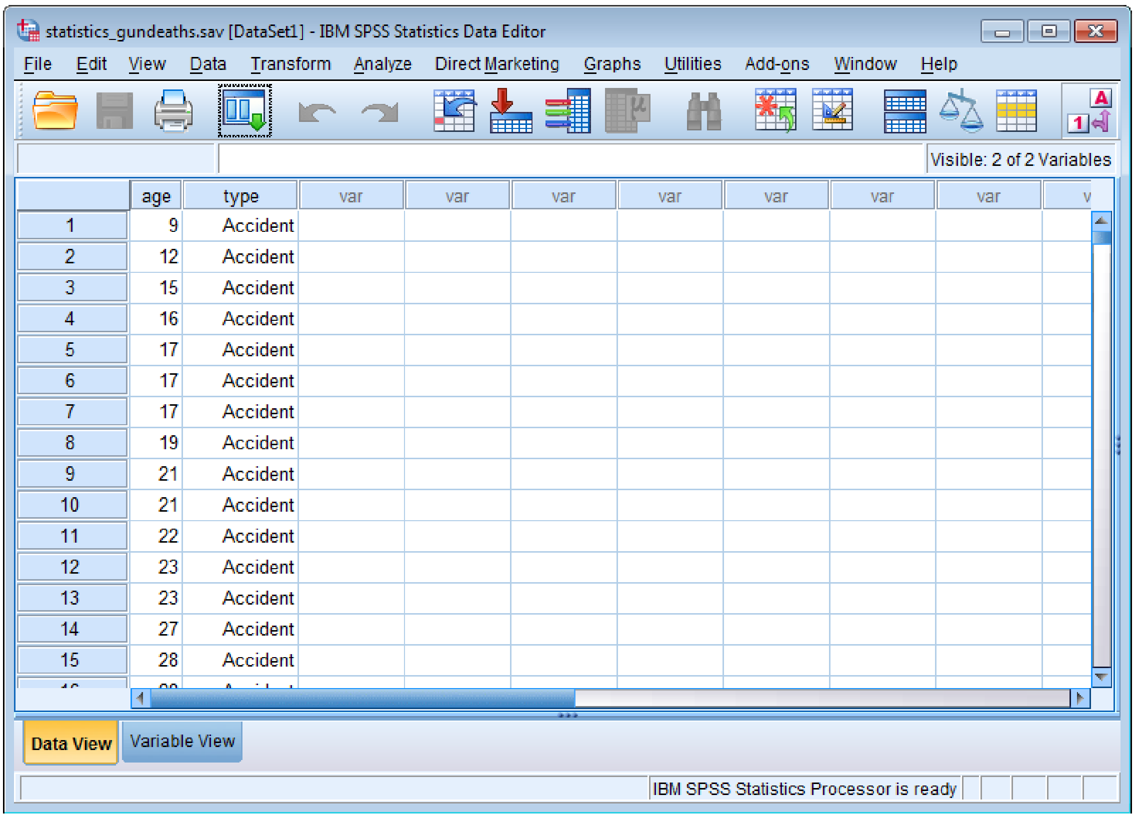
H_0:

vs H_1:

1. Open the GunDeaths.sav file from **www.tinyURL.com/stats-HTS**.

   Use a value of **1** for **Accident**, **2** for **Homicide**, **3** for **Self defense**, and **4** for **Suicide** for the **type** variable (**Values** column in the **Variable View**).

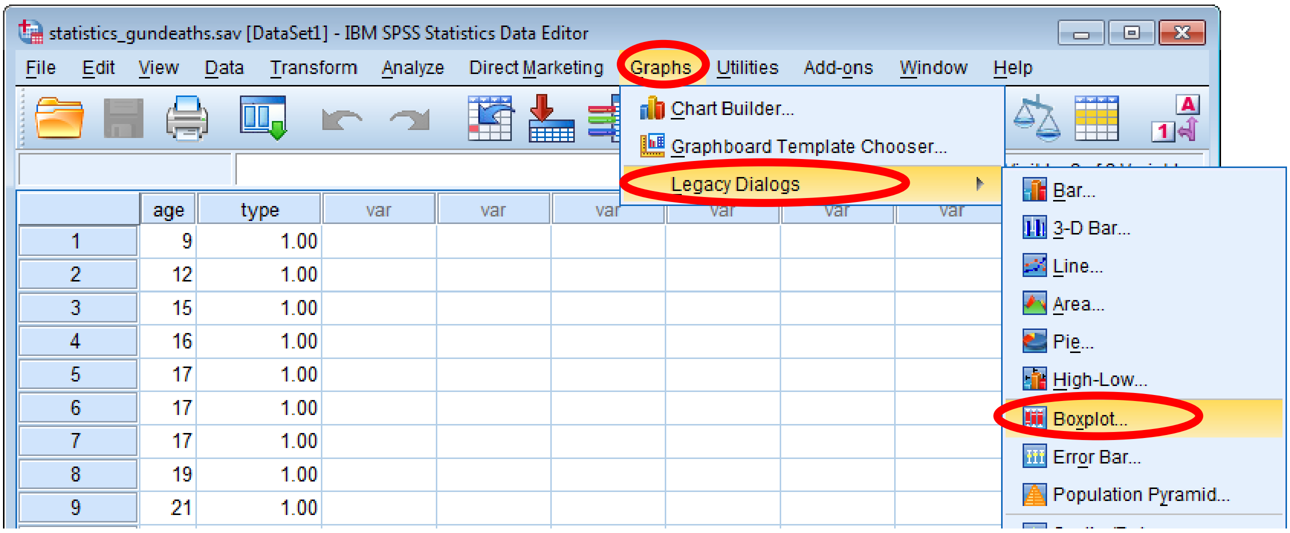
   Label **age** as **Age (in years)** and **type** as **Type of death**.



2. Plot the data using a boxplot.

a. Choose the **Boxplot** tool:

Click **Graphs** → **Legacy Dialogs** → **Boxplot**

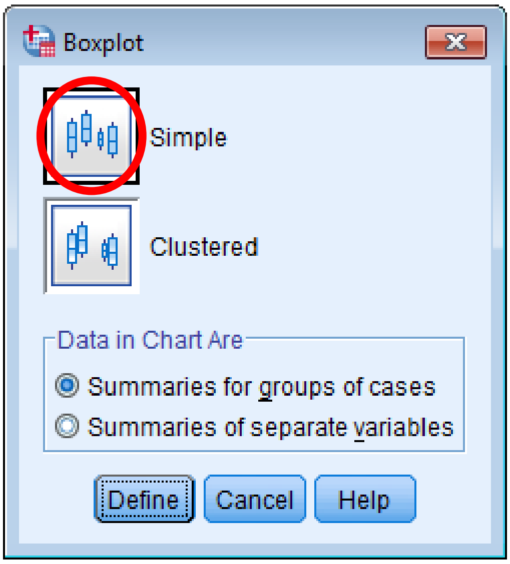


b. Pick the appropriate plot.

Simple is selected by default.

Click **Define**.

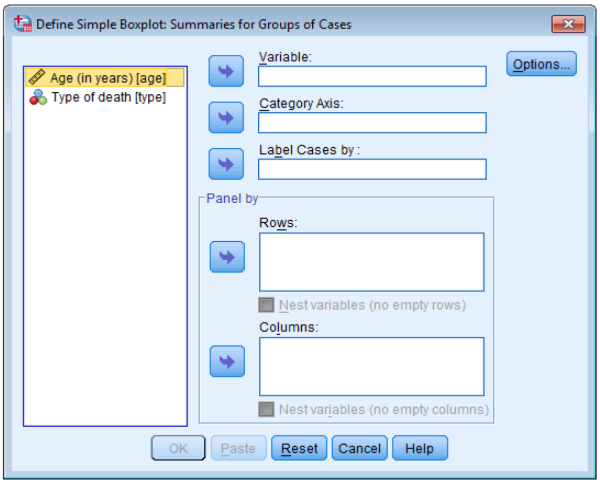
c.

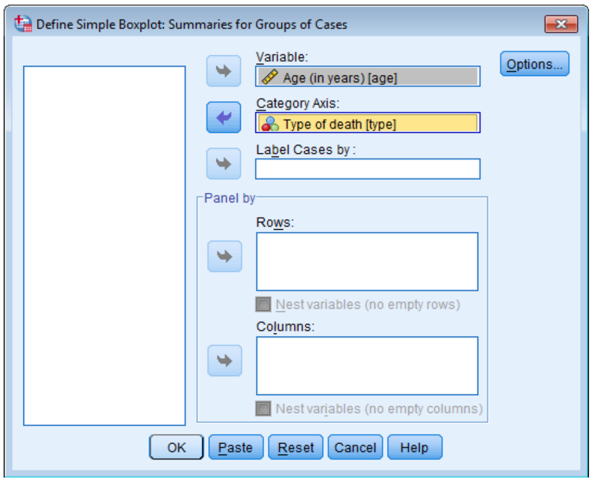


c. Assign the variables.

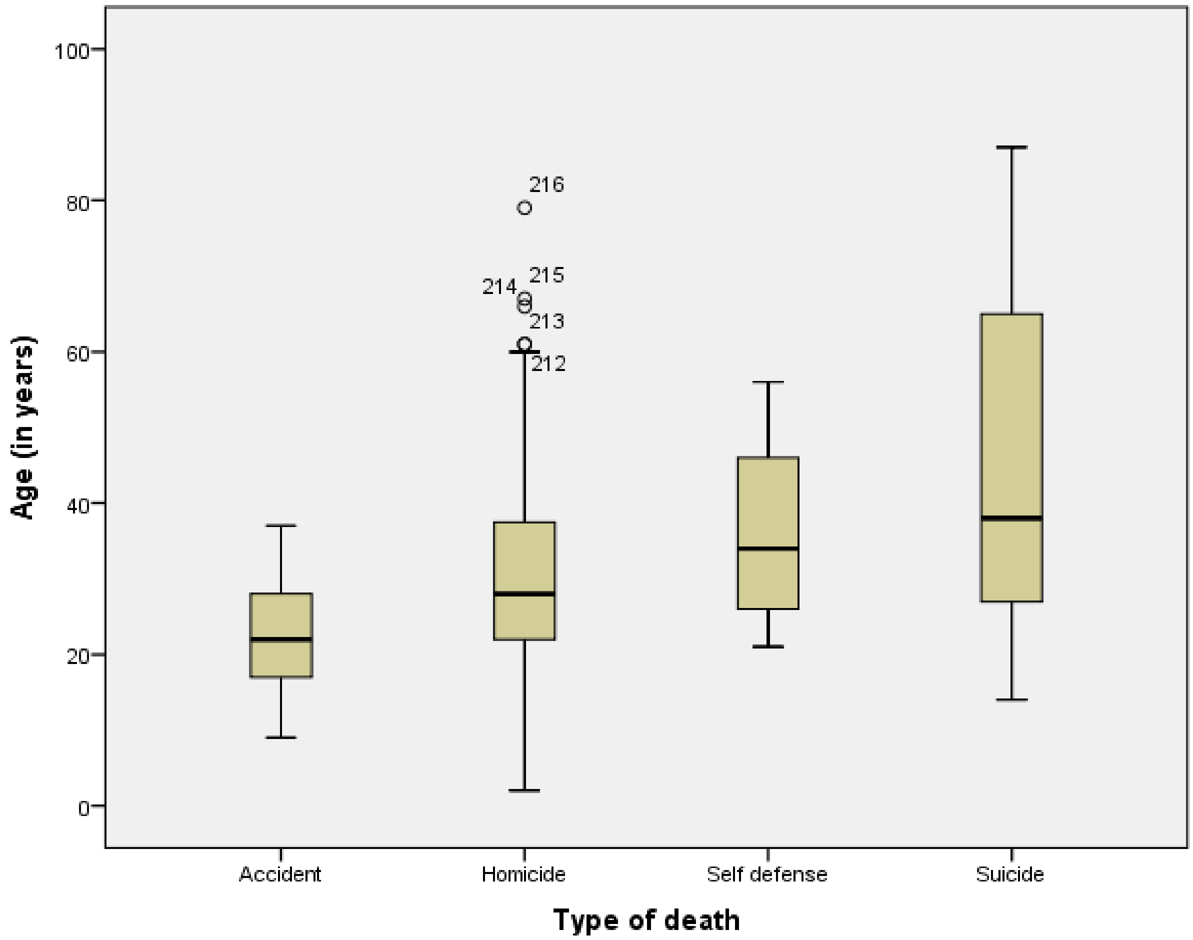
Numeric (response) variable → **Variable** box.
  Click **Age (in years) [age]**
  Click top

Categorical variable (grouping factor) → **Category Axis** box.
  Click **Type of death [type]**
  Click second





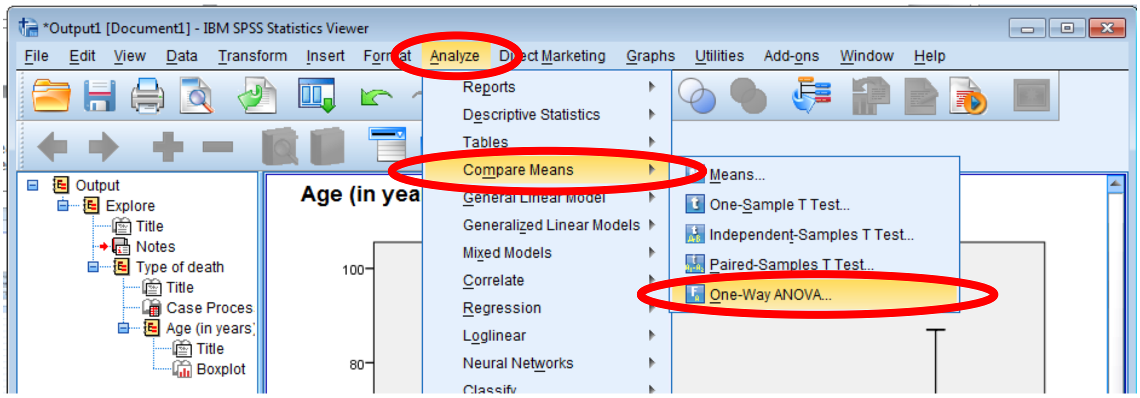
d. Click **OK**. The boxplots will appear in the **Output** window.



3. Carry out the *F*-test.

   a. Select the analysis tool: **One-Way ANOVA**.

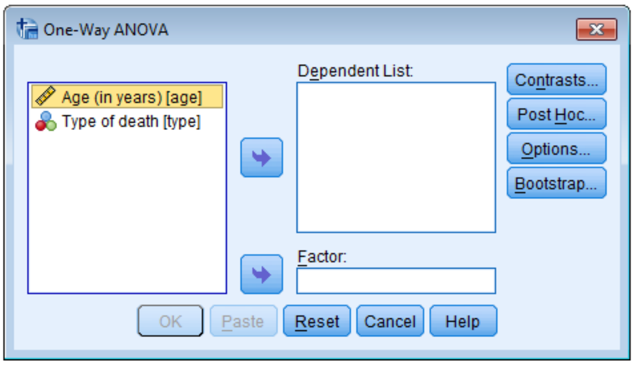
   Click **Analyze** → **Compare Means** → **One-Way ANOVA**.

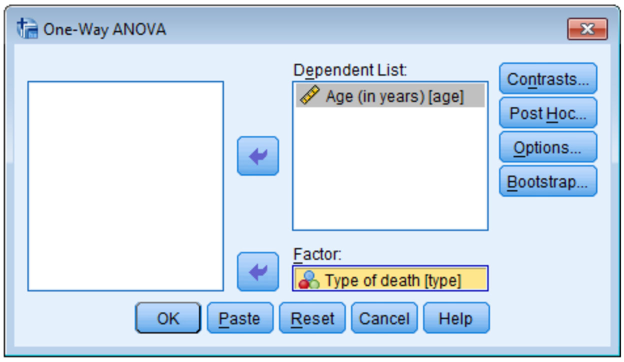


   b. Assign the variables.

   Numeric (response) variable → **Dependent List** box
      Click **Age (in years) [age]**
      Click top

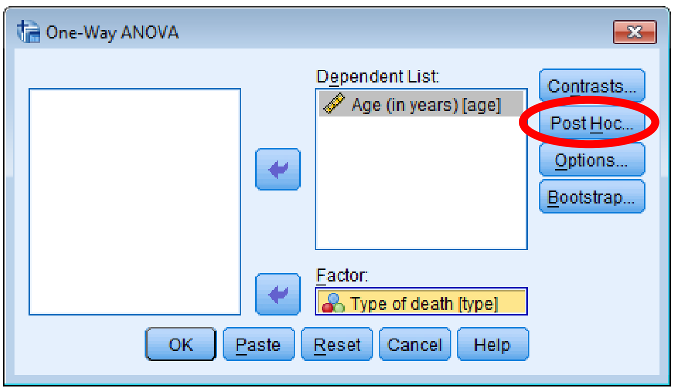
   Categorical variable (grouping factor) → **Factor** box
      Click **Type of death [type]**
      Click bottom

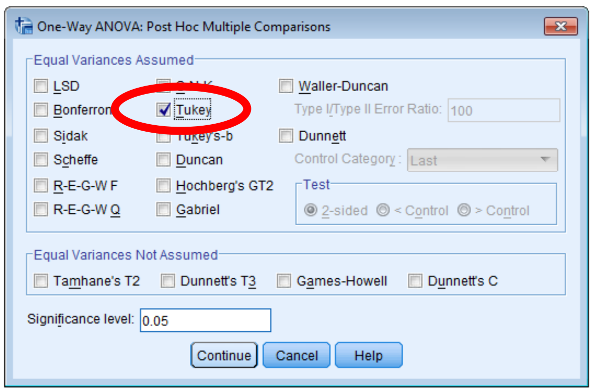




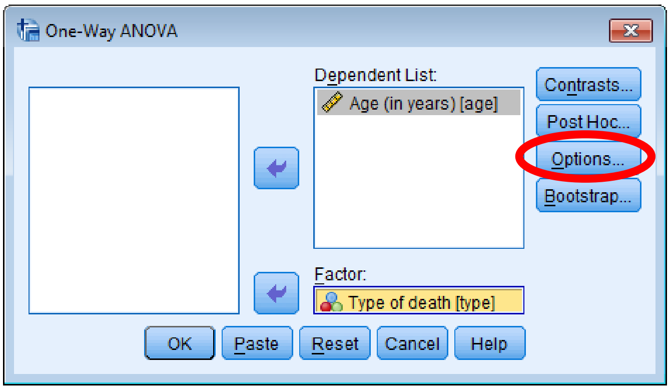
   c. Select the relevant output tables.

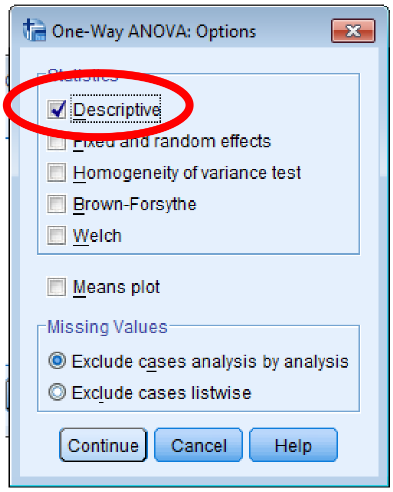
   Click **Post Hoc**. Select the **Tukey** box. Click **Continue**.





Click **Options**. Select the **Descriptive** box. Click **Continue**.





d. Click **OK**. The results will appear in the **Output** window.

Oneway

Descriptives

Age (in years)

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean Lower Bound	95% Confidence Interval for Mean Upper Bound	Minimum	Maximum
Accident	21	23.00	7.797	1.702	19.45	26.55	9	37
Homicide	195	30.86	11.879	.851	29.18	32.54	2	79
Self defense	22	35.14	10.204	2.176	30.61	39.66	21	56
Suicide	222	44.25	20.418	1.370	41.55	46.95	14	87
Total	460	37.17	17.841	.832	35.53	38.80	2	87

ANOVA

Age (in years)

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	23188.885	3	7729.628	28.676	.000
Within Groups	122915.226	456	269.551		
Total	146104.111	459			

Post Hoc Tests

Multiple Comparisons

Dependent Variable: Age (in years)
Tukey HSD

(I) Type of death	(J) Type of death	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Accident	Homicide	-7.862	3.771	.160	-17.58	1.86
	Self defense	-12.136	5.009	.074	-25.05	.78
	Suicide	-21.248*	3.748	.000	-30.91	-11.58
Homicide	Accident	7.862	3.771	.160	-1.86	17.58
	Self defense	-4.275	3.693	.654	-13.80	5.25
	Suicide	-13.386*	1.611	.000	-17.54	-9.23
Self defense	Accident	12.136	5.009	.074	-.78	25.05
	Homicide	4.275	3.693	.654	-5.25	13.80
	Suicide	-9.111	3.670	.064	-18.57	.35
Suicide	Accident	21.248*	3.748	.000	11.58	30.91
	Homicide	13.386*	1.611	.000	9.23	17.54
	Self defense	9.111	3.670	.064	-.35	18.57