

## INDEPENDENT T-TESTS: STEP-BY-STEP INSTRUCTIONS

**Please note** that the analysis tools included in the MAX toolkit require that you have Microsoft Excel 2010 or later, and that you have also installed the **Analysis ToolPak Pack** and the **Real Statistics Resource Pack** add-in programmes. Both add-ins are free to use and guidance on how to install these add-ins can be accessed [here](#).



An overview of the relevant statistical concepts used in these instructions is provided in the [Getting Started with Statistics](#) guide. An overview of independent t-tests is provided in the [exploring the differences between respondent groups guide](#) and [presentation](#),<sup>1</sup> along with an overview of analysis of variance (ANOVA), which can be used to explore more than two groups. Additional guidance is also provided in the **FURTHER ANALYSIS GUIDES**, which can be downloaded [here](#).

## INTRODUCTION

An **independent t-test** is a form of 'hypothesis testing' and can be used to determine whether there is a statistically significant difference between the means of two unrelated groups (e.g. men and women) on the same continuous dependent variable (e.g. SCRQoL). The statistical test generates a **p-value** which enables you to determine whether or not to reject the null hypothesis. This p value is the probability that the null hypothesis is true. If the p value is less than a set **significance level** (usually 5% [0.05] or 1% [0.001]), it is said that the pattern is 'statistically significant'. This means that there is a low probability that the observed pattern arose by chance.

This guide provides you with a step-by-step overview of how to conduct an independent t-test in Excel. These instructions use the following question ***Do overall social care-related quality of life***

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<sup>1</sup> Please note that independent t-tests and ANOVAs can also be used to explore the relationship between survey variables and, conversely, that cross-tabulations and chi-square tests can be used to explore the differences between respondent groups. The format of these guides and presentations were used to introduce increasingly complex concepts to MAX toolkit users and attendees of the 2016 webinars.

*(SCRQoL) scores (ASCOF 1A) differ between men and women?* but are also relevant to the PSS SACE.

## GETTING STARTED

Before running an independent t-test, ensure that your data fulfils the requirements of the statistical test. In particular, that:

1. **The dependent variable can be measured on a continuous scale:** in this instance, SCRQoL scores are measured on a scale of 0 to 24 (✓).
2. **The independent variable consists of two categorical, independent groups:** in this instance, gender includes two mutually exclusive groups – men and women (✓).
3. **Independence of observations:** each respondent must provide data for one group only and cannot be in both groups (✓). If this assumption is violated, a **paired-samples t-test** may be more suitable. Please note, however, that this test is not covered in the MAX toolkit.

The two other requirements – that the dependent variable should be normally distributed for each group (the **normal distribution** assumption) and that the variance of the dependent variable is approximately equal for each group (the **homogeneity of variances** assumption) – are tested during the analysis.

## STEP-BY-STEP INSTRUCTIONS

### STEP 1: EXTRACT DATA

Select the relevant data from your NHS Digital data return and copy and paste it into a blank Excel sheet. Ensure the data is arranged in two columns and has suitable headings.

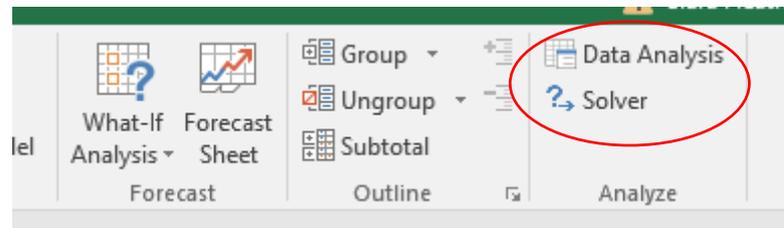
	Men	Women
	6	8
	7	8
	7	8
	8	8
	8	9

Screen shot from 'dummy' data

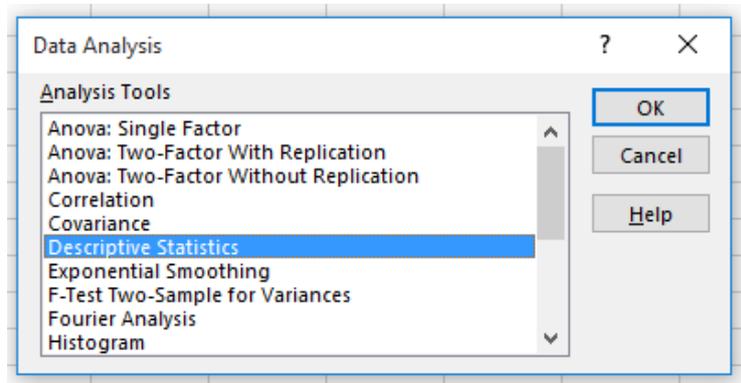
## STEP 2: CHECK WHETHER DATA IS NORMALLY DISTRIBUTED

Before you conduct an independent t-test, you need to establish whether the data is normally distributed. This assumption can be explored using the **Descriptives Statistics** function in Excel.

- I. Open data tab of Excel, select **Data Analysis** from Analyze section.



- II. In the Data Analysis window, select **Descriptive Statistics** and press **OK**.



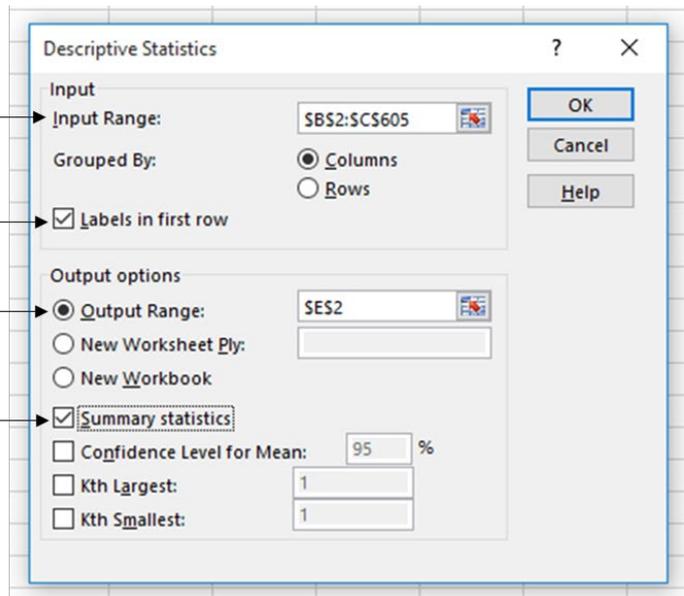
- III. In the **Descriptive Statistics window**, select the **Input Range** by clicking on . Select the entire dataset (i.e. the data for both men and women), taking care to ensure you include the row headings. Go back to **Descriptive Statistics window** and put a tick in the **Labels in first row** option. Select **output range** and **summary statistics** [in output options] and then press **OK**.

**Input range:** select entire data set (i.e. data for men + women) and include row labels

Click **Labels in first row**

**Output range:** where in Excel you would like analysis results to be posted.

Click **Summary statistics**



Note: you can also click the **Confidence level for Mean box** and amend the significance level (optional).

The descriptive statistics summary will be posted into your datasheet. **Stretch the columns** so you can see the data.

	<i>Men</i>		<i>Women</i>
Mean	18.92962	Mean	18.8408
Standard Error	0.2222	Standard Error	0.14693
Median	20	Median	19
Mode	24	Mode	19
Standard Deviation	4.103195	Standard Deviation	3.608019
Sample Variance	16.83621	Sample Variance	13.0178
Kurtosis	0.208988	Kurtosis	-0.15424
Skewness	-0.85272	Skewness	-0.57416
Range	18	Range	16
Minimum	6	Minimum	8
Maximum	24	Maximum	24
Sum	6455	Sum	11361
Count	341	Count	603

Screen shot from 'dummy' data

The extent to which a dataset is normally distributed is established using the measure of **skewness**. A frequency distribution with perfect symmetry has a skew of 0. Most distributions, however, are not perfect, and the most frequently occurring scores cluster at the lower end/left

side of the distribution (**positively skewed distributions**) or at the higher end/right side of the distribution (**negatively skewed distributions**).

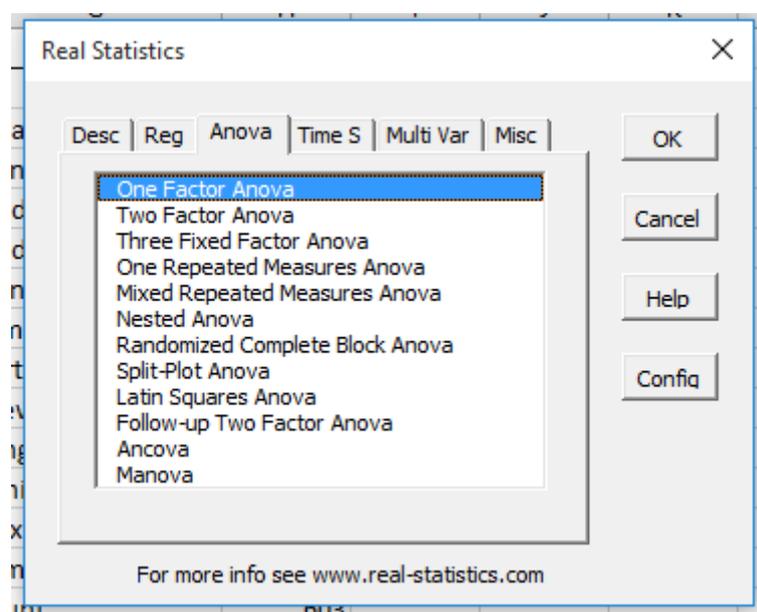
The data in this example is not normally distributed [men = -0.85 | women = -0.57]. This is probably the case for most SCRQoL data, as the majority of respondents report higher levels of quality of life, and means that the assumption of normal distribution is violated. In this instance, you should run a **Mann Whitney U Test**, the non-parametric equivalent of an independent t-test. Instructions on how to do this are provided in step 4.

### STEP 3: CHECK WHETHER VARIANCES IN DATASET ARE APPROXIMATELY EQUAL.

**Note:** if the assumption of normal distribution has been violated, you will conduct a **Mann-Whitney U Test** irrespective of the outcome of Step 3.

Before you conduct an independent t-test, you also need to establish whether the variance of the dependent variables (in this instance, SCRQoL) is approximately equal in each group. This assumption is known as the **homogeneity of variances** assumption and can be determined using the **Real Statistics** function in Excel.

1. Click **CTRL + M** to open up the **Real Statistics window**. Click on the **Anova** tab and select **One Factor ANOVA**. Press **OK**.



- II. In the **ANOVA window**, select **Input Range** (select the entire dataset, taking care to ensure you include the row headings) and **Input Format** [Excel format with column headings]. In the Options section, unselect ANOVA and select **Levene's Test**. Specify **Output Range** and press **OK**.

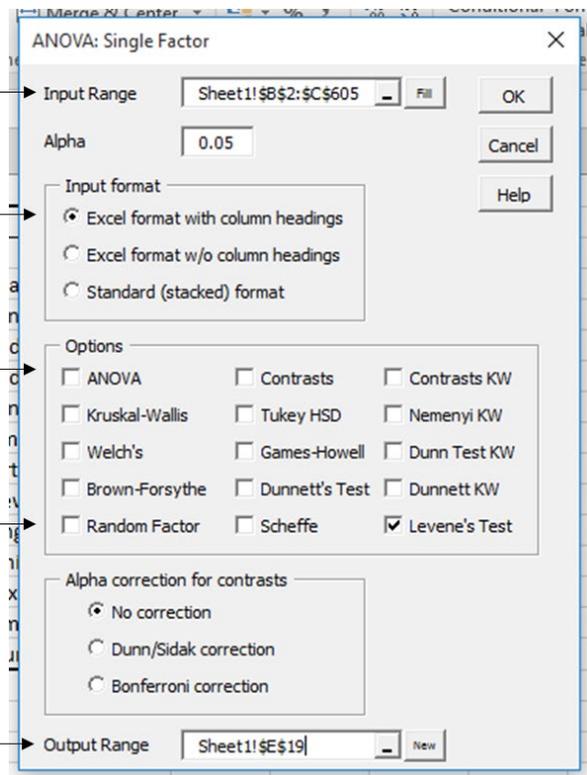
**Input range:** select entire data set (i.e. data for men + women) and include row labels

Click **Excel format with column headings**

Unselect **ANOVA**

Select **Levene's Test**

**Output range:** where in Excel you would like analysis results to be posted.



The Levene's test output will be posted into your datasheet. **If the p value is less than 0.05:** the assumption of homogeneity of variances is violated and you will need to run a **t-test with equal variances not assumed** [this is shown as t-Test: Two-Sample Assuming Unequal Variances in the Analysis Toolpak]. **If the p value is greater than 0.05:** the assumption of homogeneity of variances is not violated and you can run a **t-test with equal variances assumed** [this is shown as t-Test: Two-Sample Assuming Equal Variances in the Analysis Toolpak].

In this example, the p-value is less than 0.05 [0.017]. The assumption of homogeneity of variances has therefore been violated. As the assumption of normal distribution has also been violated you will need to run a Mann-Whitney U Test.

Levene's Tests	
type	p-value
means	0.016965
medians	0.036295
trimmed	0.018075

## STEP 4: RUN T-TEST

There are three variations of independent t-tests and the most appropriate test will be determined by your results from Steps 2 and 3. The options are summarised in the table below.

Test	Normal Distribution		Homogeneity of Variance	
	Yes	No	Yes	No
T- test with equal variances assumed	✓		✓	
T-test with equal variances not assumed	✓			✓
Mann Whitney U Test <sup>2</sup>		✓	✓	✓

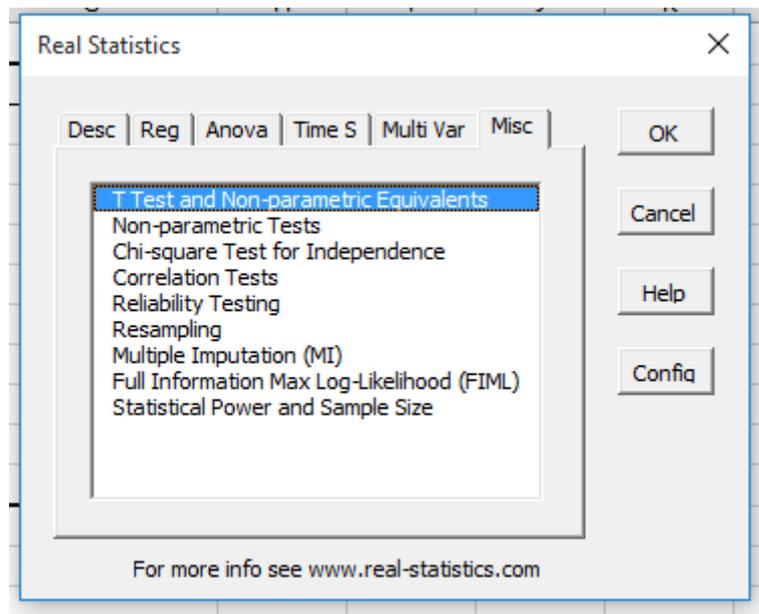
**Note:** in this example, you would run **Mann-Whitney U Test**. This is therefore outlined first.

## MANN WHITNEY U TEST

The Mann Whitney U Test is the **non-parametric equivalent** of the independent t-test and should be run when your data is not normally distributed (as it the case in this example). This analysis can be conducted in Excel but requires the **Real Statistics Resource Pack**.

- I. Click **CTRL + M** to open up the **Real Statistics window**. Click on the **Misc** tab and select **T-test and Non-parametric equivalents**. Press **OK**.

<sup>2</sup> The Mann Whitney U Test is the non-parametric equivalent of the independent t-test so does not make any assumptions about the dataset.



- II. In the **T Test and Non-parametric Equivalents** window, select **Input Range 1** [in this example, the data for men (including row heading)] and then **Input Range 2** [in this example, the data for women (including row heading)], tick **Column headings included with data**, select **Two independent samples** [in Options] and **Non-parametric** [in Test type]. Define **Output Range** and then press **OK**.

**Input range 1:** select data for 1<sup>st</sup> group (e.g. data for men) + include row labels

**Input range 2:** select data for 2<sup>nd</sup> group (e.g. data for women) + include row labels

Click **Column headings included with data**

Select **Two independent samples**

**Output range:** where in Excel you would like analysis results to be posted.

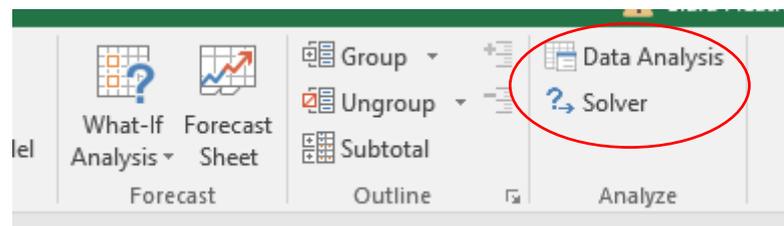
- III. Review output data. You are exploring the differences in SCRQoL scores between men and women but have not specified the direction of the relationship. You will therefore

need to look at the **p-value** for the **two-tailed hypothesis**. This is 0.255 and is not statistically significant. **Note:** the Mann-Whitney U-test confirms whether or not the result is significant in the last row.

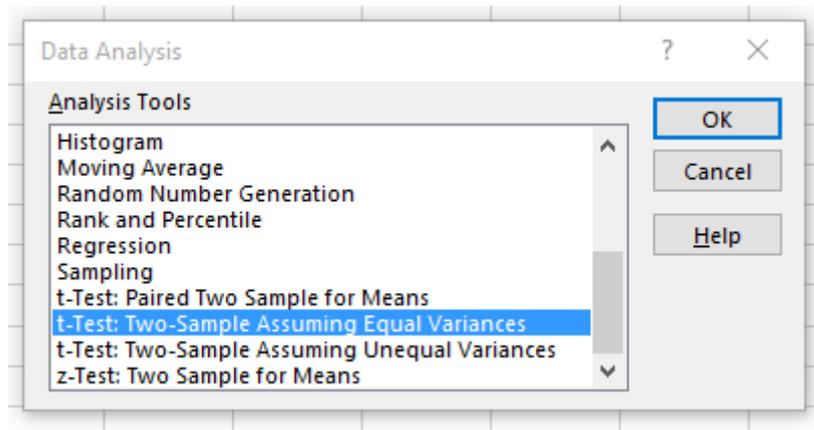
Mann-Whitney Test for Two Independent Samples		
	Men	Women
count	341	603
median	20	19
rank sum	165680.5	280359.5
U	98253.5	107369.5
	one tail	two tail
alpha	0.05	
U	98253.5	
mean	102811.5	
std dev	4008.417	ties
z-score	1.137107	
effect r	0.03701	
U-crit	96218.24	<del>94955.14799</del>
p-value	0.127747	0.255493399
sig (norm)	no	no

## T- TEST WITH EQUAL VARIANCES ASSUMED

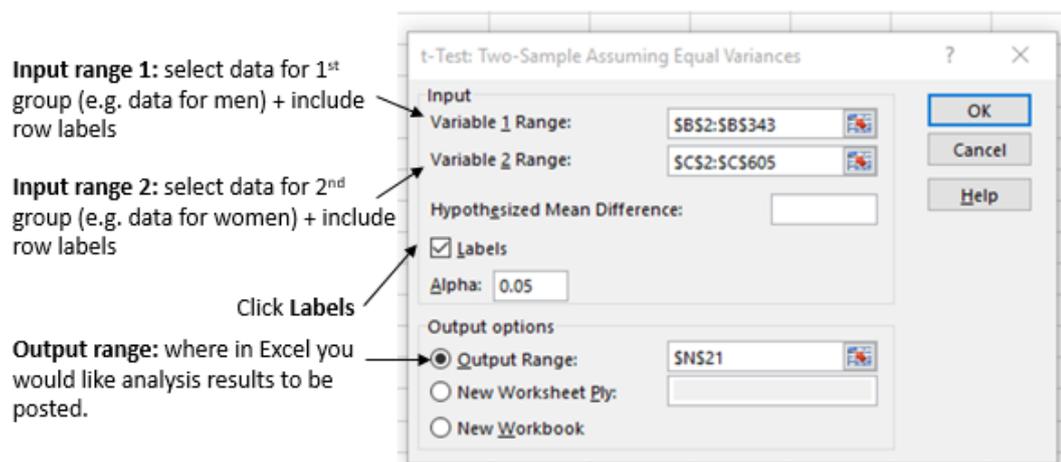
- I. Open data tab of Excel, select **Data Analysis** from Analyze section.



- II. In the **Data Analysis window**, scroll down and select **t- test: Two Sample Assuming Equal Variances**. Press **OK**.



- III. Select **Input Range** for both variables (remember to include row labels), select **Labels** and define **Output Range**. Press OK.



The test output will be posted into your datasheet. **If the p value is less than 0.05:** you can reject the null hypothesis and assert that there is a statistically significant difference between the groups. **If the p value is greater than 0.05:** you cannot reject the null hypothesis.

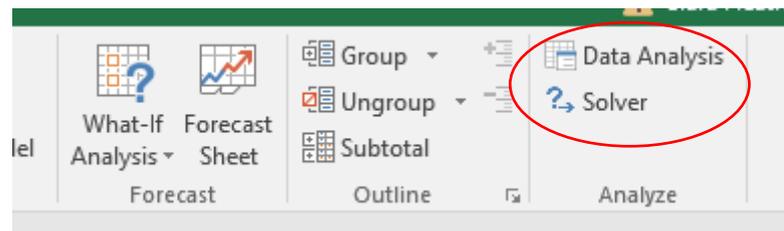
In this example, you are exploring the differences in SCRQoL scores between men and women but have not specified the direction of the relationship. You will therefore need to look at the **p-value** for the **two-tailed hypothesis**. This is 0.73 and is not therefore statistically significant.

t-Test: Two-Sample Assuming Equal Variances		
	Men	Women
Mean	18.92962	18.8408
Variance	16.83621	13.0178
Observations	341	603
Pooled Variance	14.39599	
Hypothesized Mean Difference	0	
df	942	
t Stat	0.345504	
P(T<=t) one-tail	0.364896	
t Critical one-tail	1.646473	
P(T<=t) two-tail	0.729793	
t Critical two-tail	1.962486	

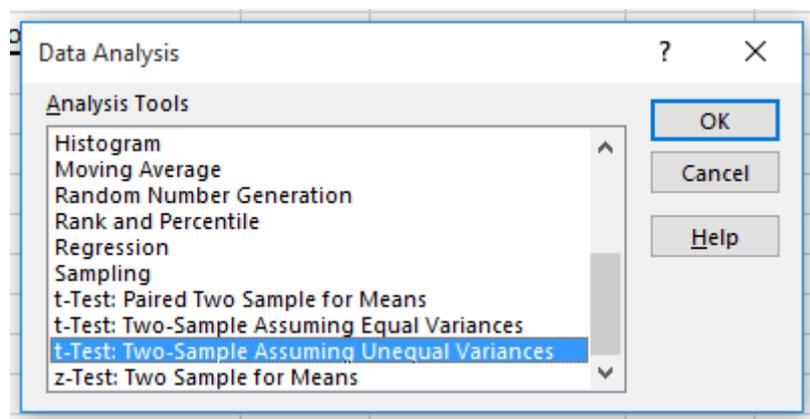
Screen shot from 'dummy' data

## T-TEST WITH EQUAL VARIANCES NOT ASSUMED

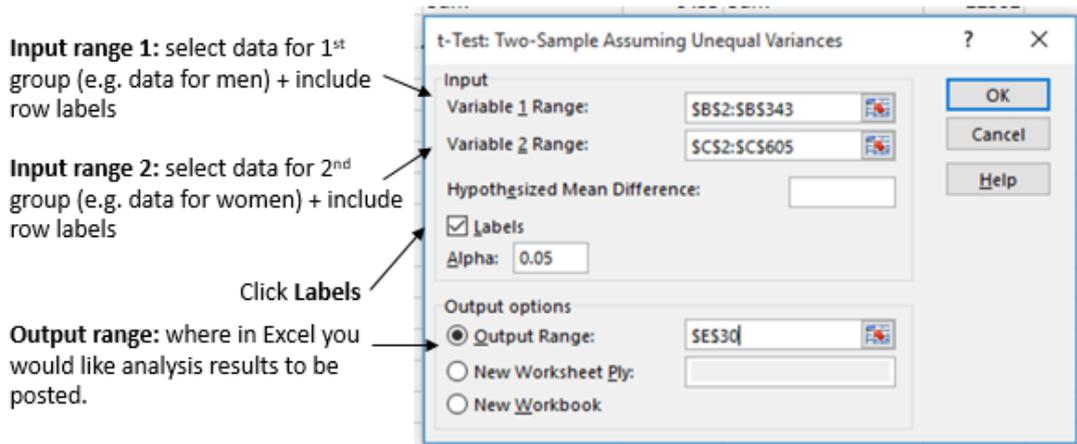
- I. Open data tab of Excel, select **Data Analysis** from Analyze section.



- II. In the Data Analysis window, **scroll down** and select **t- test: Two Sample Assuming Unequal Variances**. Press **OK**.



- III. Select **Input Range** for both variables, select **Labels** and define **Output Range**. Press OK.



The test output will be posted into your datasheet. **If the p value is less than 0.05:** you can reject the null hypothesis and assert that there is a statistically significant difference between the groups. **If the p value is greater than 0.05:** you cannot reject the null hypothesis.

t-Test: Two-Sample Assuming Unequal Variances		
	<i>Men</i>	<i>Women</i>
Mean	18.92962	18.84079602
Variance	16.83621	13.01780136
Observations	341	603
Hypothesized Mean	0	
df	634	
t Stat	0.333436	
P(T<=t) one-tail	0.369458	
t Critical one-tail	1.647261	
P(T<=t) two-tail	0.738915	
t Critical two-tail	1.963713	

Screen shot from 'dummy' data

In this example, you are exploring the differences in SCRQoL scores between men and women but have not specified the direction of the relationship. You will therefore need to look at the **p-value** for the **two-tailed hypothesis**. This is 0.74 and is not therefore statistically significant.

## INTERPRETING THE T-TEST STATISTIC

The t-tests outlined in this summary all generate a **p-value** which enables you to determine whether or not to reject the null hypothesis. This p value is the probability that the null hypothesis is true. If the p value is less than a set **significance level** (usually 5% [0.05] or 1% [0.001]) it is said that the pattern is 'statistically significant'. This means that there is a low probability that the observed pattern arose by chance.

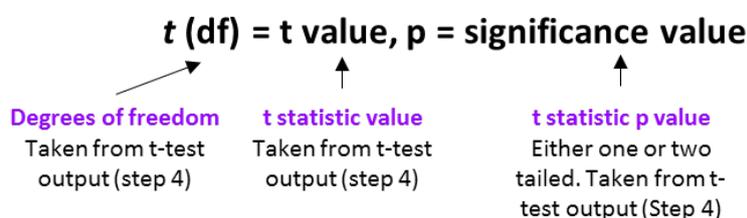
The p-value in this example is 0.25 (see Mann Whitney U Test in Step 4) and means that the **null hypothesis cannot be rejected** – in other words, *there isn't a statistically significant difference between SCRQoL scores for men and women.*

## REPORTING THE T- TEST STATISTICS

The usual format for reporting the results of any statistical test is the **test statistic** (i.e.  $X^2$  for chi-square,  $t$  for t-tests) followed by the **degrees of freedom** in brackets (i.e.  $t(634)$ ) followed by an **equals sign** and the **actual statistic value** (i.e.  $t(634) = 0.33$ ). This is then followed by a **comma** and then the **p value** (i.e.,  $p=0.19$ ). So, for t-test  $t(634) = 0.33, p = 0.74$ .

## INDEPENDENT T-TESTS

The usual format for reporting the results of an independent t- test is shown below:



You should also include the mean [M] and standard error [SE] for each group (see the Descriptives statistics output from Step 2) and report your findings in more everyday terms.

Men who responded to the adult social care survey did not report significantly different social care-related quality of life (SCRQoL) [ASCOF 1A] (M = 18.9, SE = 0.22) from women (M = 18.8, SE = 0.15), (t (634) = 0.33, p = 0.74).

Men		Women	
Mean	18.92962	Mean	18.8408
Standard Error	0.2222	Standard Error	0.14693
Median	20	Median	19
Mode	24	Mode	19
Standard Deviation	4.103195	Standard Deviation	3.608019
Sample Variance	16.83621	Sample Variance	13.0178
Kurtosis	0.208988	Kurtosis	-0.15424
Skewness	-0.85272	Skewness	-0.57416
Range	18	Range	16
Minimum	6	Minimum	8
Maximum	24	Maximum	24
Sum	6455	Sum	11361
Count	341	Count	603

t-Test: Two-Sample Assuming Unequal Variances		
	Men	Women
Mean	18.92962	18.84079602
Variance	16.83621	13.01780136
Observations	341	603
Hypothesized Mean	0	
df	634	
t Stat	0.333436	
P(T<=t) one-tail	0.369458	
t Critical one-tail	1.647261	
P(T<=t) two-tail	0.738915	
t Critical two-tail	1.963713	

## MANN WHITNEY U TESTS

The format for reporting the results of a Mann Whitney U- test is slightly different from the independent t-test as you include the median [Mdn], rather than the mean [M], for each group and do not include the degrees of freedom.

**U = u value, p = significance value**

↑  
**u statistic value**  
 Taken from output  
 (step 4)

↑  
**u statistic p value**  
 Either one or two  
 tailed. Taken from  
 output (Step 4)

In this instance, you could report your results as follows: **Social care-related quality of life (SCRQoL) scores [ASCOF 1A] for men (Mdn = 20) did not differ significantly from women (Mdn = 19) (U = 94955.47, p = 0.26).**

Mann-Whitney Test for Two Independent Samples		
	Men	Women
count	341	603
median	20	19
rank sum	165680.5	280359.5
U	98253.5	107369.5
	one tail	two tail
alpha	0.05	
U	98253.5	
mean	102811.5	
std dev	4008.417	ties
z-score	1.137107	
effect r	0.03701	
U-crit	96218.24	94955.14799
p-value	0.127747	0.255493399
sig (norm)	no	no

**A word of caution:** a significant association does not imply causation but does identify potential important relationships that should be further explored using multi-variate and/or themed analysis. Additional guidance is provided in the **FURTHER ANALYSIS GUIDES** included in the MAX toolkit and can be downloaded [here](#).

## DISCLAIMER

The MAX toolkit and website are based on independent research commissioned and funded by the NIHR Policy Research Programme (Maximising the value of survey data in adult social care (MAX) project and the MAX toolkit implementation and impact project). The views expressed on the website and in publications are those of the author(s) and not necessarily those of the NHS, the NIHR, the Department of Health and Social Care or its arm's length bodies or other government departments.