

## Tutorial: Non-Parametric Tests in Stata

### The Sign Test and Wilcoxon Signed-Rank Test

Consider the following table taken from Whitley and Ball (2002) showing central venous oxygen saturation in 10 patients at admission and 6 hours after admission to an intensive care unit (ICU).

Table 1: Central Venous Oxygen Saturation (%)

<i>Subject</i>	<i>At admission</i>	<i>6 hours after admission to ICU</i>
1	39.7	52.9
2	59.1	56.7
3	56.1	61.9
4	57.7	71.4
5	60.6	67.7
6	37.8	50.0
7	58.2	60.7
8	33.6	51.3
9	56.0	59.5
10	65.3	59.8

E. Whitley and J. Ball. Statistics review 6: Nonparametric methods. Crit Care. 2002; 6(6): 509–513.

It is hypothesized that after 6 hours in the ICU central venous oxygen saturation should increase. The authors are interested in whether the apparent increase in central venous oxygen saturation is likely to reflect a genuine effect of admission and treatment or whether it is simply due to chance.

The data are located in the `cvos.dta` data set. In this example we want to know whether there is a difference in central venous oxygen saturation at admission compared to 6 hours after admission to the ICU. That is, we want to know whether 6 hours in the ICU has an effect on central venous oxygen saturation.

1. Are the data independent or dependent? What parametric and nonparametric tests are available for this type of data?

Dependent: We measure central venous oxygen saturation at admission and 6 hours after admission on the *same* subject.

Parametric test: paired t- test

Non-parametric tests: sign test, Wilcoxon Signed-Rank Test

2. What type of statistical test is most appropriate for this data and why?

We should probably use a non-parametric test since we have a small sample size. Furthermore, we have no information to suggest that the differences are normally distributed. You could also make a histogram of the differences to inspect normality.

3. Suppose we decide to use the sign test. What are the null and alternative hypotheses?

The null hypothesis is that the median of the differences is equal to zero. The alternative is that the median of the differences is not equal to zero.

4. Perform a sign test in Stata at  $\alpha = 0.05$ . What is the value of your test statistic? Your p-value? Your decision? Your interpretation?

You may use the following drop-down menus to access the `signtest` command:  
Statistics / Summaries, tables, and tests / Nonparametric tests of hypotheses / Test equality of matched pairs.

```
. signtest t6=t0
```

Sign test

sign	observed	expected
positive	8	5
negative	2	5
zero	0	0
all	10	10

One-sided tests:

Ho: median of  $t6 - t0 = 0$  vs.

Ha: median of  $t6 - t0 > 0$

Pr(#positive  $\geq 8$ ) =

Binomial( $n = 10, x \geq 8, p = 0.5$ ) = 0.0547

Ho: median of  $t6 - t0 = 0$  vs.

Ha: median of  $t6 - t0 < 0$

Pr(#negative  $\geq 2$ ) =

Binomial( $n = 10, x \geq 2, p = 0.5$ ) = 0.9893

Two-sided test:

Ho: median of  $t6 - t0 = 0$  vs.

Ha: median of  $t6 - t0 \neq 0$

Pr(#positive  $\geq 8$  or #negative  $\geq 8$ ) =

$\min(1, 2 \cdot \text{Binomial}(n = 10, x \geq 8, p = 0.5)) = 0.1094$

Our test statistics is  $D = 8$ , since we have two plus signs. Stata uses the binomial distribution to generate the p-value. Our p-value is 0.1094. Thus, we fail to reject the null hypothesis and conclude that we do not find evidence that median central venous oxygen saturation is different at admission and 6 hours after admission to the ICU using the sign test.

5. Suppose that instead of conducting the sign test we conduct the Wilcoxon signed-rank test. Which test has more power? Why?

The signed-rank test has more power since it incorporates the magnitude of differences via the ranks.

6. State the null and alternative hypothesis for the Wilcoxon signed-rank test.

The null hypothesis is that the median of the differences is equal to zero. The alternative is that the median of the differences is not equal to zero.

7. Perform a signed-rank test in Stata at the  $\alpha = 0.05$  level. What is the value of your test statistic? Your p-value? Your decision? Your interpretation?

You may use the following drop-down menus to access the `signrank` command:  
Statistics / Summaries, tables, and tests / Nonparametric tests of hypotheses / Wilcoxon matched-pairs signed-rank test

```
. signrank t6=t0
```

Wilcoxon signed-rank test

sign	obs	sum ranks	expected
positive	8	50	27.5
negative	2	5	27.5
zero	0	0	0
all	10	55	55

unadjusted variance	96.25
adjustment for ties	0.00
adjustment for zeros	0.00
-----	
adjusted variance	96.25

Ho:  $t6 = t0$

z =	2.293
Prob >  z  =	0.0218

Our test statistic is 2.293. The p-value is 0.0218. Therefore, we reject the null hypothesis. Thus, we have evidence that median central venous oxygen saturation is different at admission and 6 hours after admission to the ICU. It appears that central venous oxygen saturation is higher after 6 hours in the ICU.