# 11 Summary & Review

## *11.1 Art of Hypothesis testing revisited*

1. Clarify assumptions and express things in a mathmatical model
2. Formulate hypotheses
3. Compute a relevant test statistic
4. Perform test and obtain P-value
5. Draw conclusion

## *11.2 Checking Normailty*

Visual insection (histogram; boxplot; normal-QQ plot);
Shapiro-Wilk test of normality
Example

## *11.3 Topic-Method Grid*

| *Topic* | *Data* | *Procedure* | *Estimator/CI* | *Equivalent Parametric Procedures* | *Note* |
|---|---|---|---|---|---|
| Checking normality | Any | Visual insection (histogram; boxplot; normal-QQ plot); Shapiro-Wilk test of normality | | | hist; boxplot; qqnorm; shapiro.test; |
| Binomial | Outcome of independent Bernoulli trials | Binomial test | Binomial estimator,CI | | rbinom |
| One-sample location | Paired replicates | Wilcoxon signed rank test | Hodges Lehmann estimator (median of Walsh | t-test, sample mean | wilcox.test |

| | | | | | |
|---|---|---|---|---|---|
| | | | averages) | | |
| | Paired replicates | Fisher sign test | Sample median | t-test, sample mean | |
| | One-sample $Z_1,..,Z_n$ | Similar | Similar | | |
| Two-sample location | X1,…,Xm and Y1,…,Yn | Wilcoxon-Mann-Whitney rank sum test | Hodges-Lehmann estimator | Two-sample t-test, difference of sample means | wilcox.test |
| Two-sample dispersion | X1,…,Xm and Y1,…,Yn | Ansari-Bradley test | | Two-sample F-test | ansari.test |
| Two-sample difference | X1,…,Xm and Y1,…,Yn | Kolmogorov-Smirnov | | | ks.test |
| One-way layout | $X_{ij}$ | Kruskal-Wallis test | | One-way ANOVA | kruskal.test |
| Two-way layout | $X_{ijt}$ | Friedman test | | Two-way ANOVA | friedman.test |
| Independence | (X1,Y1),…,(Xn,Yn) | Kendall test<br>Spearman test | Kentall's tau<br>Spearman's rank correlation | Correlation<br>Correlation | cor(…)<br>cor(…) |
| Comparing two rates | Outcome of two independent sets of Bernoulli trials | Pearson test | | | chisq.test |
| | | Fisher exact test | | | fisher.test |

## 11.4 Final notes

People use "nonparametric statstics" to mean different things
Kernel density estimation, nonparameteric regression etc…

Thank you!

## 11.5 HW #4 Solutions

8.1. With n=10 and $\alpha$=.054, $k_{.054}$=19. Test H0: $\tau$=0 vs $\tau$>0. K=-7. Can't reject H0 since K<19.

8.4*. P(Y2>Y1, X2>X1)=3/8 after multiple integration. By symmetry, P(Y2<Y1, X2<X1)= P(Y2>Y1, X2>X1)=3/8. Thus, $\tau$=2(3/8+3/8)-1 = ½.
8.20. $\tau$-hat = 2K/(n(n-1)) = 2(-7)/(10*9) = -.1556
10.12 In R, run

```
fisher.test(matrix(c(0,5,2,1),byrow=TRUE,nrow=2), alternative='less')
```

It gives P-value 0.1071. Can't reject the null hypothesis at $\alpha$=.05.
10.13. E11 = 1.25, E21=.75, E12=3.75, E22=2.25 and $\chi^2$=4.444. The P-value = P($\chi^2$>4.444)=.035. We reject the null hypothesis at $\alpha$=.05.

### 11.5.1 Chapter 7 (Two-way analysis) practice question.

Go over the lecture note and try Problem 7.1.

The solution is below:
"For testing H0: $\tau_1$=$\tau_1$=$\tau_1$ vs H1: $\tau_i$ are not all equal, use Firedman test. Obtain R1=9.5, R2=5, R3=9.5. The statistic S' = 12[(9.5-8)2 + …] / (12x4 – ½(22+13-3)) = 3.6 and the approximate P-value provided by Minitab is p=P(S'>3.6)=0.166."