

Coursera - Statistical Inference Project

By Mandy Jiang (03/02/2022)

Part II. Basic inferential data analysis

We're going to analyze the ToothGrowth data in the R datasets package.

(1) Load the ToothGrowth data and perform some basic exploratory data analyses. \ (2) Provide a basic summary of the data. \ (3) Use confidence intervals and/or hypothesis tests to compare tooth growth by supp and dose. (Only use the techniques from class, even if there's other approaches worth considering) \ (4) State your conclusions and the assumptions needed for your conclusions.

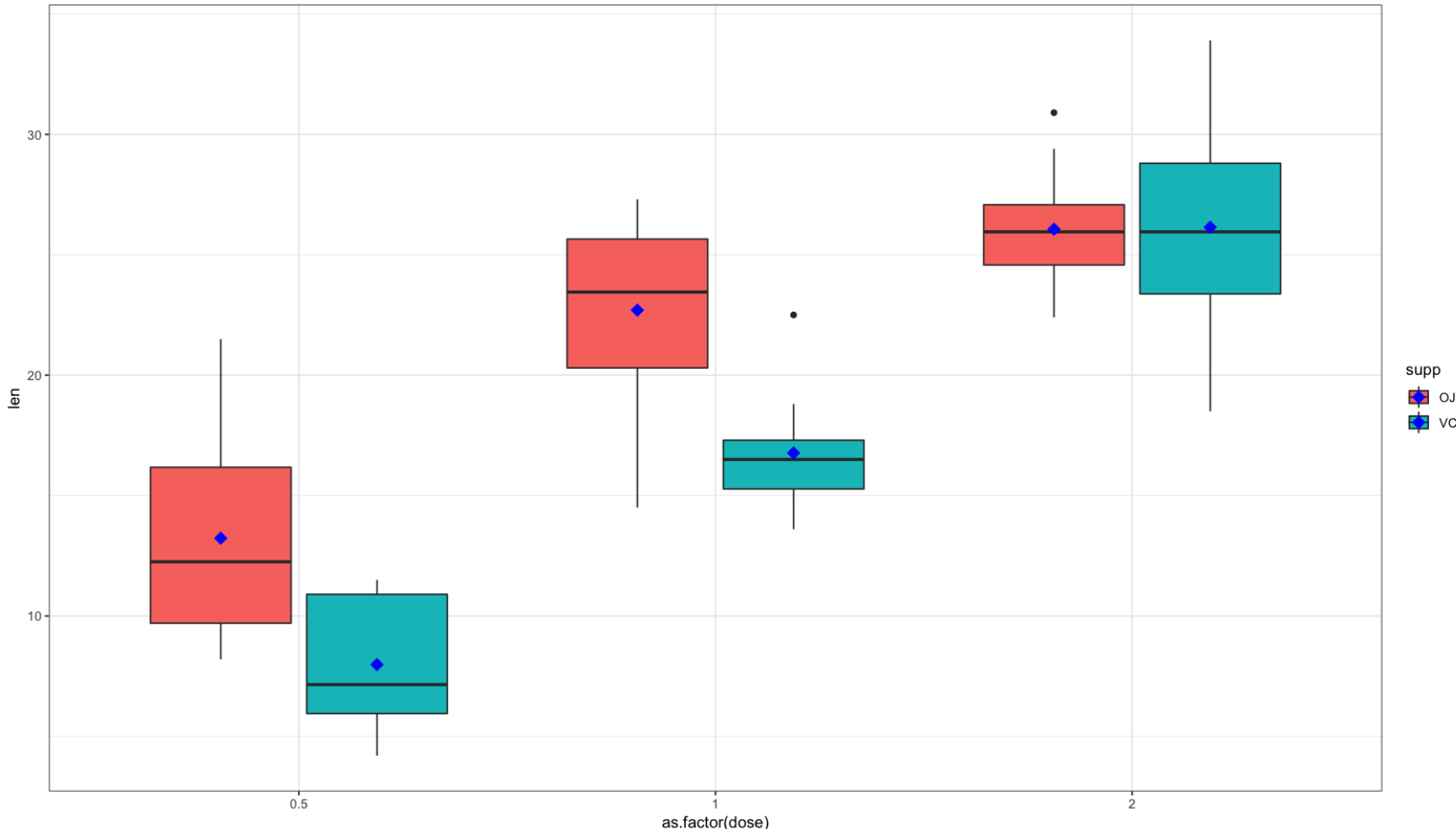
Summary and exploratory data analyses

```
In [32]: ToothGrowth %>%
  group_by(supp, dose) %>%
  summarise(mean = mean(len), median = median(len), min = min(len), max = max(len), sd=sd(len), n = n())
```

supp	dose	mean	median	min	max	sd	n
OJ	0.5	13.23	12.25	8.2	21.5	4.459709	10
OJ	1.0	22.70	23.45	14.5	27.3	3.910953	10
OJ	2.0	26.06	25.95	22.4	30.9	2.655058	10
VC	0.5	7.98	7.15	4.2	11.5	2.746634	10
VC	1.0	16.77	16.50	13.6	22.5	2.515309	10
VC	2.0	26.14	25.95	18.5	33.9	4.797731	10

This dataset contains 2 supp methods, OJ and VC, and each methods have 3 dose groups, 0.5, 1 and 2. By observing mean and median, length in dose of 1 and 2 is almost 2-fold to the one in dose of 0.5. Also, the length difference is more obvious in VC than OJ when comparing dose of 1 and 2.

```
In [65]: library(ggplot2)
p = ggplot(ToothGrowth, aes(x=as.factor(dose), y=len, fill=supp)) +
  geom_boxplot() +
  stat_summary(fun.y=mean, geom="point", shape=18, size=4, color="blue", position=position_dodge(0.75)) +
  theme_bw()
options(p.plot.width = 0.5, p.plot.height = 0.5)
p
```



The boxplot shows that higher dose is associated with longer len in both OJ and VC mode. In addition, OJ is associated with longer length than VC in 0.5 and 1 dose but not in 2.

Hypothesis tests

(1) First, we are going to test whether supp methods have impacts on len. Null hypothesis: \ H0: supp has no impacts on len. \ We are going to use unpaired t-test to validate the hypothesis.

```
In [1]: t.test(ToothGrowth$len[ToothGrowth$supp == "VC"],ToothGrowth$len[ToothGrowth$supp == "OJ"], paired=FALSE)

Welch Two Sample t-test

data:  ToothGrowth$len[ToothGrowth$supp == "VC"] and ToothGrowth$len[ToothGrowth$supp == "OJ"]
t = -1.9153, df = 55.309, p-value = 0.06063
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -7.5710156  0.1710156
sample estimates:
mean of x mean of y
 16.96333  20.66333
```

Given that p-value = 0.06063 > 0.05, the t statistic falls on the left side of reject region; therefore we cannot reject null hypothesis. In addition, the 95% confident interval contains mean difference = 0, indicating no significant difference between these two supp modes.

(2) Second, we are going to test whether dose have impacts on len. Null hypothesis: \ H0: dose has no impacts on len. \ We are going to use unpaired t-test to validate the hypothesis.

```
In [8]: t.test(ToothGrowth$len[ToothGrowth$dose == 0.5],ToothGrowth$len[ToothGrowth$dose == 1], paired=FALSE)$p.value
t.test(ToothGrowth$len[ToothGrowth$dose == 0.5],ToothGrowth$len[ToothGrowth$dose == 2], paired=FALSE)$p.value
t.test(ToothGrowth$len[ToothGrowth$dose == 1],ToothGrowth$len[ToothGrowth$dose == 2], paired=FALSE)$p.value

1.26830072017385e-07
4.39752495936323e-14
1.9064295136718e-05
```

Given that p-value < 0.05 across three doese comparison, the t statistic falls on the right side of reject region; therefore we can reject the null hypothesis.

(3) Third, we are going to test whether supp methods have impacts on len within each dose. \ H0: supp has no impacts on len given dose to 0.5, 1, and 2. \ H1: OJ causes longer len than VJ given dose to 0.5, 1 and 2. \ We are going to use unpaired t-test to validate the hypothesis.

```
In [10]: dose_0.5 = ToothGrowth[ToothGrowth$dose == 0.5,]
dose_1.0 = ToothGrowth[ToothGrowth$dose == 1,]
dose_2.0 = ToothGrowth[ToothGrowth$dose == 2,]
```

```
In [25]: t.test(dose_0.5$len[dose_0.5$supp == 'OJ'],dose_0.5$len[dose_0.5$supp == 'VC'],
  paired=FALSE,alternative='greater')$p.value
t.test(dose_0.5$len[dose_0.5$supp == 'OJ'],dose_0.5$len[dose_0.5$supp == 'VC'],
  paired=FALSE,alternative='greater')$conf.int
```

0.0031793033820484

- 2.34604034665748
- Inf

Given dose to 0.5, the probability of OJ is greater than VC is about 0.00317 (p-value < 0.05), and therefore we can reject the null hypothesis and state that OJ causes longer len than VJ under the dose of 0.5.

```
In [26]: t.test(dose_1.0$len[dose_1.0$supp == 'OJ'],dose_1.0$len[dose_1.0$supp == 'VC'],
  paired=FALSE,alternative='greater')$p.value
t.test(dose_1.0$len[dose_1.0$supp == 'OJ'],dose_1.0$len[dose_1.0$supp == 'VC'],
  paired=FALSE,alternative='greater')$conf.int
```

0.000519187936149939

- 3.35615763634793
- Inf

Given dose to 1, the probability of OJ is greater than VC is about 0.00052 (p-value < 0.05), and therefore we can reject the null hypothesis and state that OJ causes longer len than VJ under the dose of 1.

```
In [29]: t.test(dose_2.0$len[dose_2.0$supp == 'OJ'],dose_2.0$len[dose_2.0$supp == 'VC'],
  paired=FALSE,alternative='greater')$p.value
t.test(dose_2.0$len[dose_2.0$supp == 'OJ'],dose_2.0$len[dose_2.0$supp == 'VC'],
  paired=FALSE,alternative='greater')$conf.int
t.test(dose_2.0$len[dose_2.0$supp == 'OJ'],dose_2.0$len[dose_2.0$supp == 'VC'],
  paired=FALSE,alternative='two.sided')$p.value
```

0.518074205638314

- 3.13349957439956
- Inf

0.963851588723373

Given dose to 2, the probability of OJ is greater than VC is about 0.51807 (p-value > 0.05), and therefore we cannot reject the null hypothesis. In addition, p-value is 0.96385 > 0.05 in two-sided test, indicating that supp mothods have no impacts on len under the dose of 2.

Conclusions

(1) The does has significant influence on the teeth growth; higher dose is associated with longer length. \ (2) The supp methods has significant influence on the teeth growth if the dose is 0.5 and 1; however, supp has no impacts on teeth growth if the dose is 2. \ (3) If supp methods can impact teeth growth, OJ is associated with longer length than VJ mode.