Statistical Inference Course Project Part 2

Overview

In the second part of this project, we're going to analyze the ToothGrowth data in the R datasets package.

Instructions

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, using only techniques from class.
4. State your conclusions and the assumptions needed for your conclusions.

Exploratory Data Analyses

First, load the data and examine its structure

```
# Load required packages
library(ggplot2)

# Load data
data("ToothGrowth")

# Examine structure
str(ToothGrowth)
```

```
## 'data.frame':    60 obs. of  3 variables:
##  $ len : num  4.2 11.5 7.3 5.8 6.4 10 11.2 11.2 5.2 7 ...
##  $ supp: Factor w/ 2 levels "OJ","VC": 2 2 2 2 2 2 2 2 2 2 ...
##  $ dose: num  0.5 0.5 0.5 0.5 0.5 0.5 0.5 0.5 0.5 0.5 ...
```

Next, let's do a basic summary of the data

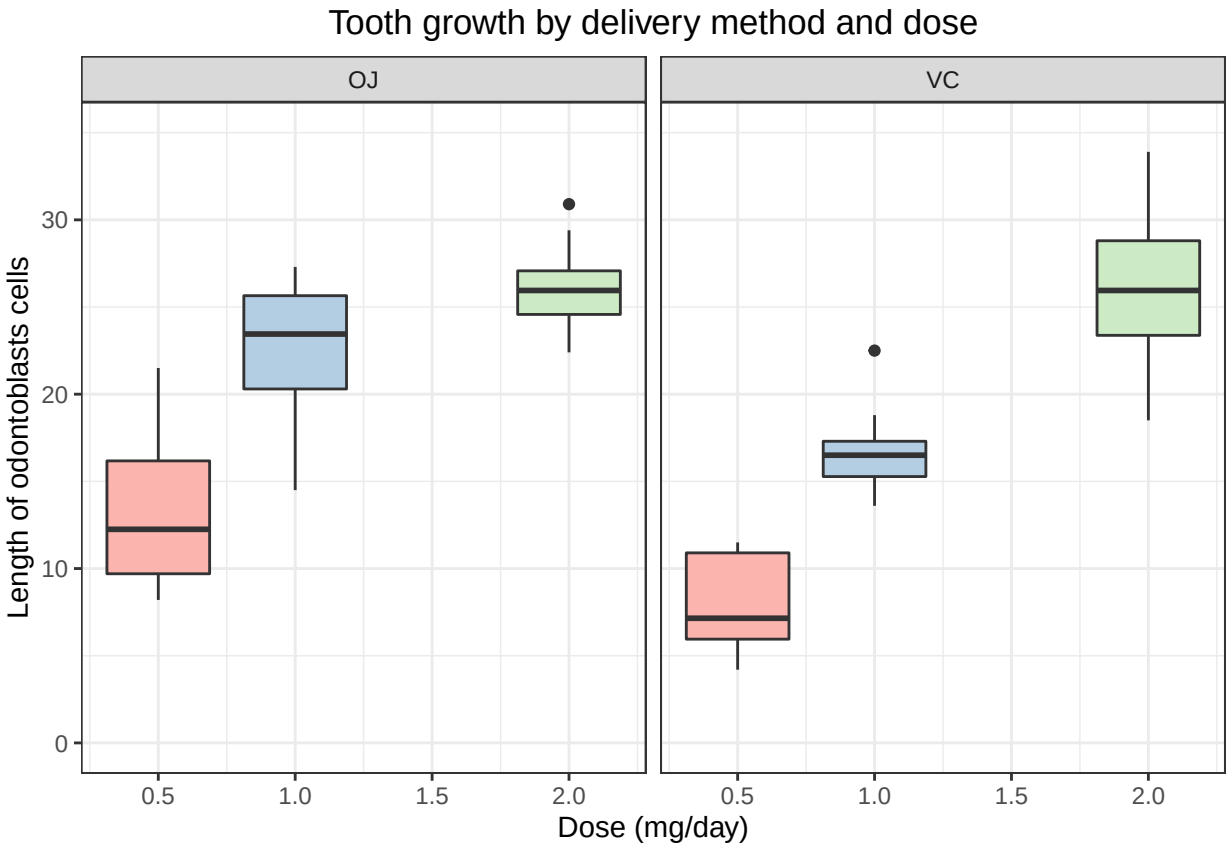
```
summary(ToothGrowth)
```

```
##       len        supp         dose
##  Min.   : 4.20   OJ:30   Min.   :0.500
##  1st Qu.:13.07   VC:30   1st Qu.:0.500
##  Median :19.25           Median :1.000
##  Mean   :18.81           Mean   :1.167
##  3rd Qu.:25.27           3rd Qu.:2.000
##  Max.   :33.90           Max.   :2.000
```

Let's plot the summary of tooth growth by delivery method and dose

```
ggplot(ToothGrowth, aes(x = dose, y = len)) +
  geom_boxplot(aes(fill = factor(dose)), show.legend = FALSE) +
  facet_grid(. ~ supp) +
  labs(x = "Dose (mg/day)",
```

```
      y = "Length of odontoblasts cells",
      title = "Tooth growth by delivery method and dose"
      ) +
  ylim(range(pretty(c(0, ToothGrowth$len)))) +
  theme_bw() +
  scale_fill_brewer(palette="Pastel1") +
  theme(plot.title = element_text(hjust = 0.5))
```



Hypothesis Testing

Does Vitamin C delivery method affect tooth growth?

The first hypothesis we will test is as follows: H_0: The Vitamin C delivery method (orange juice vs ascorbic acid) does not affect tooth growth (i.e. The difference in means between both methods equals 0). H_1: The Vitamin C delivery method (orange juice vs ascorbic acid) affects tooth growth. (i.e. The difference in means between both methods does not equal 0).

Run t-test

```
t.test(len~supp, data = ToothGrowth)
```

```
##
##  Welch Two Sample t-test
##
```

```
## data:  len by supp
## 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:
##  -0.1710156  7.5710156
## sample estimates:
## mean in group OJ mean in group VC
##         20.66333         16.96333
```

Given that the p-value is about 0.06 and the confidence interval (CI) contains 0, we fail to reject the null hypothesis. The delivery method of Vitamin C does not seem to affect tooth growth.

Does Vitamin C dosing affect tooth growth?

The next hypothesis we will test is as follows: H_0: The Vitamin C dose does not affect tooth growth (i.e. The difference in means between doses equals 0). H_1: The Vitamin C dose affects tooth growth (i.e. The difference in means between doses does not equal 0).

Because there are 3 different doses, we will run 2 t-tests.

```
options(scipen = 999)

# Run t-test for doses 0.5 mg/day vs 1.0 mg/day
dose.subset1 <- subset(ToothGrowth, ToothGrowth$dose %in% c(0.5, 1.0))
ttest1 <- t.test(len~dose, data = dose.subset1)
ttest1
```

```
##
##  Welch Two Sample t-test
##
## data:  len by dose
## t = -6.4766, df = 37.986, p-value = 0.0000001268
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -11.983781  -6.276219
## sample estimates:
## mean in group 0.5   mean in group 1
##            10.605            19.735
```

```
# Run t-test for doses 1.0 mg/day vs 2.0 mg/day
dose.subset2 <- subset(ToothGrowth, ToothGrowth$dose %in% c(1.0, 2.0))
ttest2 <- t.test(len~dose, data = dose.subset2)
ttest2
```

```
##
##  Welch Two Sample t-test
##
## data:  len by dose
## t = -4.9005, df = 37.101, p-value = 0.00001906
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -8.996481 -3.733519
## sample estimates:
```

```
## mean in group 1 mean in group 2
##          19.735          26.100
```

The p-values for both tests are much smaller than 0.05, and all CIs do not overlap with 0, suggesting that Vitamin C dose has an impact on tooth growth.

However, since we did multiple comparisons, let's do a Bonferroni correction to see if our results still hold.

```
# Store all p-values in a vector
pvals <- c(ttest1$p.value, ttest2$p.value)

# Do Bonferroni correction
adjusted.pvals <- p.adjust(pvals, method = "bonferroni")

# Calculate number of significant p-values
sum(adjusted.pvals < 0.05)
```

```
## [1] 2
```

After Bonferroni correction, both p-values are still significant. So, our results still hold.

Conclusions

Assuming that (1) the ToothGrowth data sample is representative of the population, and (2) the distribution of the sample means is approximately normal, we can conclude the following: 1. Delivery method of Vitamin C does not have an impact on tooth growth. 2. Vitamin C dose does affect tooth growth. Specifically, the higher the dose, the larger the tooth growth.