The Effect of Vitamin C on Tooth Growth in Guinea Pigs

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Overview

In this project I want to analyze the effect of vitamin C on tooth growth in guinea pigs using ToothGrowth data in the R datasets package. First I'll perform some basic exploratory data analyses, and then use hypothesis tests to compare tooth growth by supplement type and dose level.

Exploratory data analyses

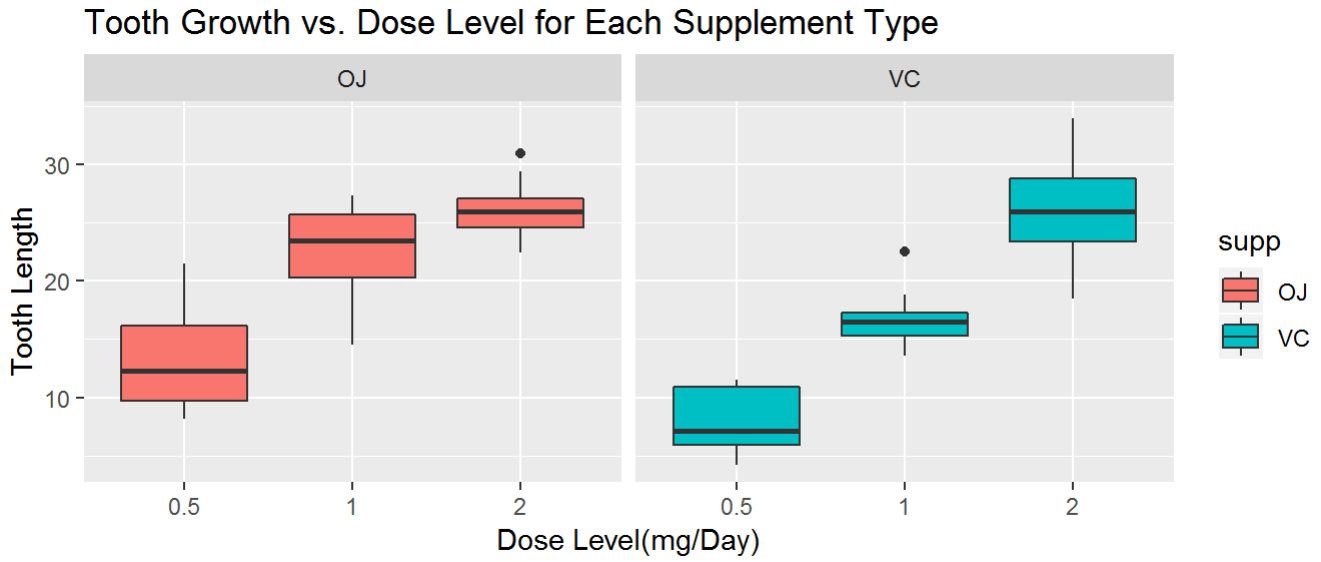
```
## Warning: package 'ggplot2' was built under R version 3.4.4
```

```
## '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 ...
```

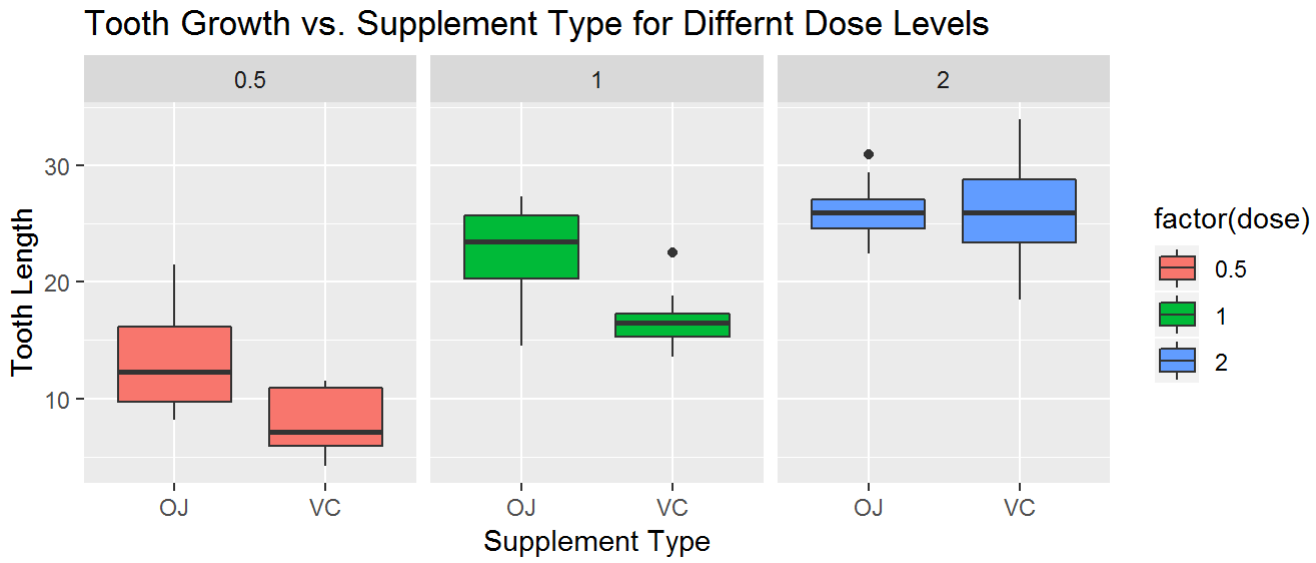
```
## [1] 0.5 1.0 2.0
```

ToothGrowth data includes 60 observations of 3 variables:
len: numeric variable - tooth length
supp: factor variable with 2 levels: "OJ"(Orange Juice) and "VC"(Vitamin C)
dose: numeric valriable - Dose in milligrams/day

Each animal received one of three dose levels of vitamin C (0.5, 1, and 2 mg/day) by one of two delivery methods, orange juice or ascorbic acid (a form of vitamin C and coded as VC). The responseis the length of odontoblasts (cells responsible for tooth growth) in 60 guinea pigs.



Looking at box plots, I can say by increaing dosage, tooth growth increases for both delivery method(orange juice and Vitamin C).



For lower dosages(0.5, 1) orange juice has been more effective, but for dosage = 2, we can't make a conclusion.

Hypothesis Tests

Hypothesis 1: The supplement type doesn't effect on the tooth growth

```
##
##  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
```

p-value(0.06) > significant value(0.05),so I fail to reject the null hypothesis.

Hypothesis 2: The dose levels '1' and '2' have the same effect on the tooth growth

```
##
##  Welch Two Sample t-test
##
## data:  len by dose
## t = -4.9005, df = 37.101, p-value = 1.906e-05
## 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
```

P-value(1.906e-05) < significance value(0.05), so I reject the null hypothesis. Tooth growth is not the same for dose = 1 and dose = 2.

Hypothesis 3: The dose levels ‘1’ and ‘0.5’ have the same effect on the tooth growth

```
##
##  Welch Two Sample t-test
##
## data:  len by dose
## t = -6.4766, df = 37.986, p-value = 1.268e-07
## 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
```

P-value(1.268e-07) < significance value(0.05), so I reject the null hypothesis. Tooth growth is not the same for dose = 1 and dose = 0.5.

Hypothesis 4: The dose levels ‘2’ and ‘0.5’ have the same effect on the tooth growth

```
##
##  Welch Two Sample t-test
##
## data:  len by dose
## t = -11.799, df = 36.883, p-value = 4.398e-14
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -18.15617 -12.83383
## sample estimates:
## mean in group 0.5   mean in group 2
##            10.605            26.100
```

P-value(4.398e-14) < significance value(0.05), so I reject the null hypothesis. Tooth growth is not the same for dose = 2 and dose = 0.5.

Conclusion

I investigated ToothGrowth dataset to see if there is any differnce in guinea pig’s tooth growth based on the type and dose level of vitamin C supplement they recieved. To naswer this question I performed four independent two-sample t-tests assuming the followings:
- The two samples in each test are independent.
- The two samples in each test follow normal distributions.
- The two samples in each test have differnt variance.

These are my test results:
The supplement type doesn’t effect the tooth growth, however the extra dose increases the tooth growth.

Appendix

Exploratory Data Analysis

```
# Load required packages
library(ggplot2)
#Load data
data("ToothGrowth")
#Show statistics
str(ToothGrowth)
#Show Unique values
unique(ToothGrowth$dose)
```

```
#First Plot
ggplot(ToothGrowth, aes(x = factor(dose), y = len)) +
  geom_boxplot(aes(fill = supp))+
  facet_grid(.~supp)+
  ggtitle("Tooth Growth vs. Dose Level for Each Supplement Type")+
  xlab("Dose Level(mg/Day)")+
  ylab("Tooth Length")

#Second Plot
ggplot(ToothGrowth, aes(x = supp, y = len, fill = factor(dose))) +
  geom_boxplot()+
  facet_grid(.~dose)+
  ggtitle("Tooth Growth vs. Supplement Type for Differnt Dose Levels ")+
  xlab("Supplement Type")+
  ylab("Tooth Length")
```

Hypothesis Tests

Hypothysis 1

```
t.test(len ~ supp, ToothGrowth, paired = FALSE, var.equal = FALSE)
```

Hypothysis 2

```
ToothGrowth12 <- subset(ToothGrowth, dose %in% c(1,2)) #select doses 1 and 2 from dataset
t.test(len ~ dose, ToothGrowth12, paired = FALSE, var.equal = FALSE)
```

Hypothysis 3

```
ToothGrowth12 <- subset(ToothGrowth, dose %in% c(1,0.5))#select doses 1 and .5 from dataset
t.test(len ~ dose, ToothGrowth12, paired = FALSE, var.equal = FALSE)
```

Hypothysis 4

```
ToothGrowth12 <- subset(ToothGrowth, dose %in% c(2,0.5))#selec doses 2 and .5 from dataset
t.test(len ~ dose, ToothGrowth12, paired = FALSE, var.equal = FALSE)
```