# The Effect of Vitamin C on Tooth Growth in Guinea Pigs

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## Overview

The purpose of the this exercise is to analyze the ToothGrowth data set by comparing the guinea tooth growth by supplement and dose. We will perform the following:

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.

## Load ToothGrowth data and perform exploratory data analyses

### ToothGrowth {datasets}

*The Effect of Vitamin C on Tooth Growth in Guinea Pigs*

**Description**

The response is the length of odontoblasts (teeth) in each of 10 guinea pigs at each of three dose levels of Vitamin C (0.5, 1, and 2 mg) with each of two delivery methods (orange juice or ascorbic acid). **Usage** ToothGrowth **Format**

A data frame with 60 observations on 3 variables. [,1] len : Tooth length {numeric} [,2] supp : Supplement type (VC or OJ) {factor} [,3] dose : Dose in milligrams {numeric}

**Source** C. I. Bliss (1952) *The Statistics of Bioassay.* Academic Press.

**References** McNeil, D. R. (1977) *Interactive Data Analysis.* New York: Wiley.

```
library(datasets)
data(ToothGrowth)
dim(ToothGrowth)
```

```
## [1] 60  3
```

```
head(ToothGrowth)
```

```
##    len supp dose
## 1  4.2   VC  0.5
## 2 11.5   VC  0.5
## 3  7.3   VC  0.5
## 4  5.8   VC  0.5
## 5  6.4   VC  0.5
## 6 10.0   VC  0.5
```

## Provide 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
```

Get information about the tooth decay lengths:

```
c(
    round(mean(ToothGrowth$len),3),
    round(sd(ToothGrowth$len),3),
    round(var(ToothGrowth$len),3)
)
```

```
## [1] 18.813  7.649 58.512
```

Turn dosages into factors, instead of numerics. This will make graphing easier.

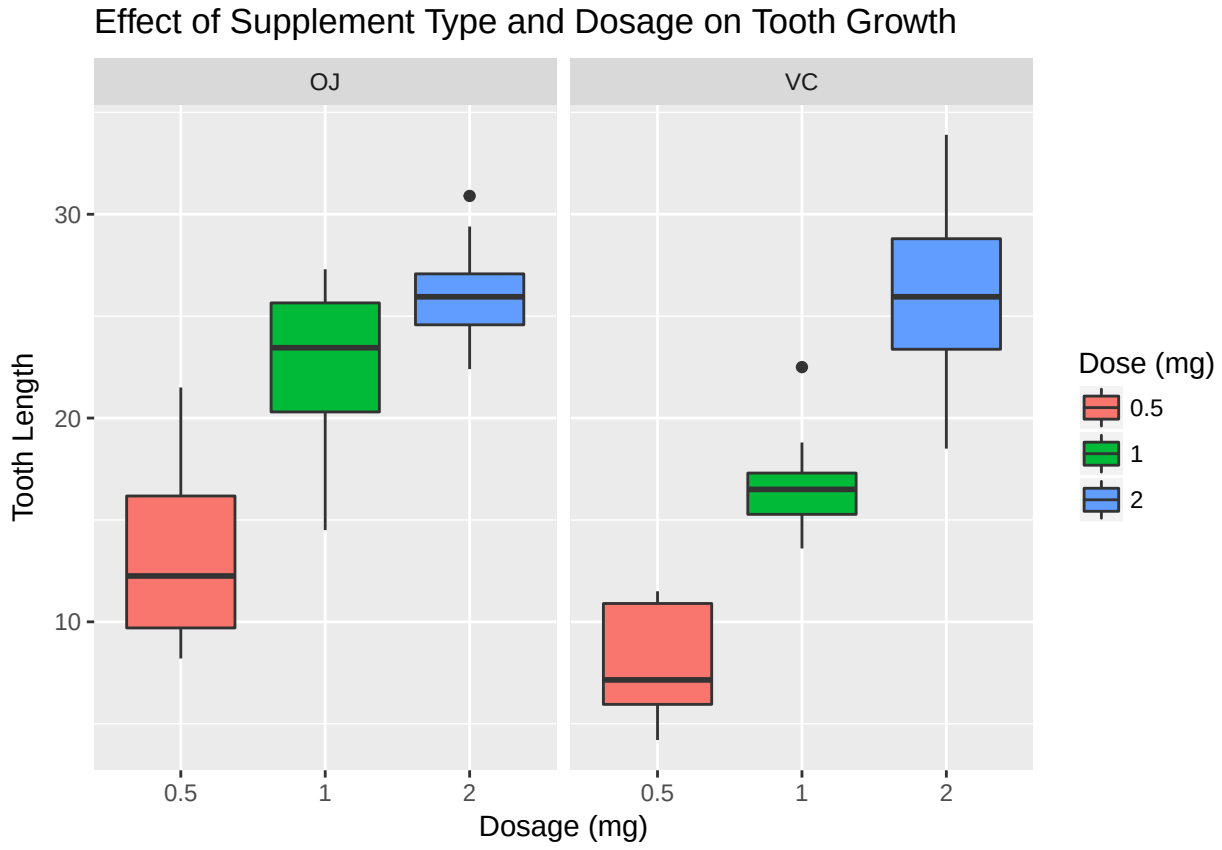
```
ToothGrowth$dose <- as.factor(ToothGrowth$dose)
summary(ToothGrowth)
```

```
##       len        supp     dose
##  Min.   : 4.20   OJ:30   0.5:20
##  1st Qu.:13.07   VC:30   1  :20
##  Median :19.25           2  :20
##  Mean   :18.81
##  3rd Qu.:25.27
##  Max.   :33.90
```

## 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)

Graphical analysis of data:

```
library(ggplot2)
ggplot(
    ToothGrowth,
    aes(x=factor(dose),y=len,fill=factor(dose))
) +
    geom_boxplot(notch=F) +
    facet_grid(.~supp) +
    scale_x_discrete("Dosage (mg)") +
    scale_y_continuous("Tooth Length") +
    scale_fill_discrete(name="Dose (mg)") +
    ggtitle("Effect of Supplement Type and Dosage on Tooth Growth")
```




**The 95% condifence intervals per-interval:**

```
alpha <- 1 - 0.95
availabledosages <- c(0.5, 1, 2)
statnames <- c("OJ-mean","OJ-lower","OJ-upper","VC-mean","VC-lower","VC-upper")
dosagematrix <- matrix(
    nrow = 0,
    ncol = length(statnames)
)
for(rowname in availabledosages){
    x <- ToothGrowth$len[ToothGrowth$supp=="OJ" & ToothGrowth$dose == rowname]
    y <- ToothGrowth$len[ToothGrowth$supp=="VC" & ToothGrowth$dose == rowname]
    dosagematrix <- rbind(
        dosagematrix,
        c(
            round(mean(x),2),
            round(mean(x) - qnorm(1-alpha/2) * sd(x)/sqrt(length(x)),2),
            round(mean(x) + qnorm(1-alpha/2) * sd(x)/sqrt(length(x)),2),
            round(mean(y),2),
            round(mean(y) - qnorm(1-alpha/2) * sd(y)/sqrt(length(y)),2),
            round(mean(y) + qnorm(1-alpha/2) * sd(y)/sqrt(length(y)),2)
        )
    )
}
```

```
rownames(dosagematrix) <- availabledosages
colnames(dosagematrix) <- statnames
```

**0.5mg dosage**

| OJ-mean | OJ-lower | OJ-upper | VC-mean | VC-lower | VC-upper |
|---|---|---|---|---|---|
| 13.23 | 10.47 | 15.99 | 7.98 | 6.28 | 9.68 |

**1.0mg dosage**

| OJ-mean | OJ-lower | OJ-upper | VC-mean | VC-lower | VC-upper |
|---|---|---|---|---|---|
| 22.70 | 20.28 | 25.12 | 16.77 | 15.21 | 18.33 |

**2.0mg dosage**

| OJ-mean | OJ-lower | OJ-upper | VC-mean | VC-lower | VC-upper |
|---|---|---|---|---|---|
| 26.06 | 24.41 | 27.71 | 26.14 | 23.17 | 29.11 |

## State your conclusions and the assumptions needed for your conclusions.

Based on the analysis:

- For lower dosages (0.5mg and 1.0 mg), OJ provides more tooth growth than VC;
- For 2.0mg dosage tooth growth is the same for both supplement methods;
- Higher dosages give more growth, independent of supplement method