# Tooth Growth Analysis

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## Overview:

This analysis examines the effects of vitamin C on tooth growth in guinea pigs. Each of the 60 guinea pigs studied received one of three doses of vitamin C per day: 0.5, 1.0, or 2.0 mg/day. There were two delivery methods: orange juice (OJ) and ascorbic acid (VC). The response measures the growth in odontoblasts (cells responsible for tooth growth).

```
# Load dataset
library(datasets)
data("ToothGrowth")
```

## Exploratory analysis

```
# List length of rows / columns
dim(ToothGrowth)
```

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

```
# Determine column data types
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 ...
```

```
# Range of tooth growth
range(ToothGrowth$len)
```

```
## [1]  4.2 33.9
```

```
# Levels and counts of delivery methods/supplements
table(ToothGrowth$supp)
```

```
##
## OJ VC
## 30 30
```

```
# Levels and counts of dosages
table(ToothGrowth$dose)
```

```
##
## 0.5   1   2
##  20  20  20
```

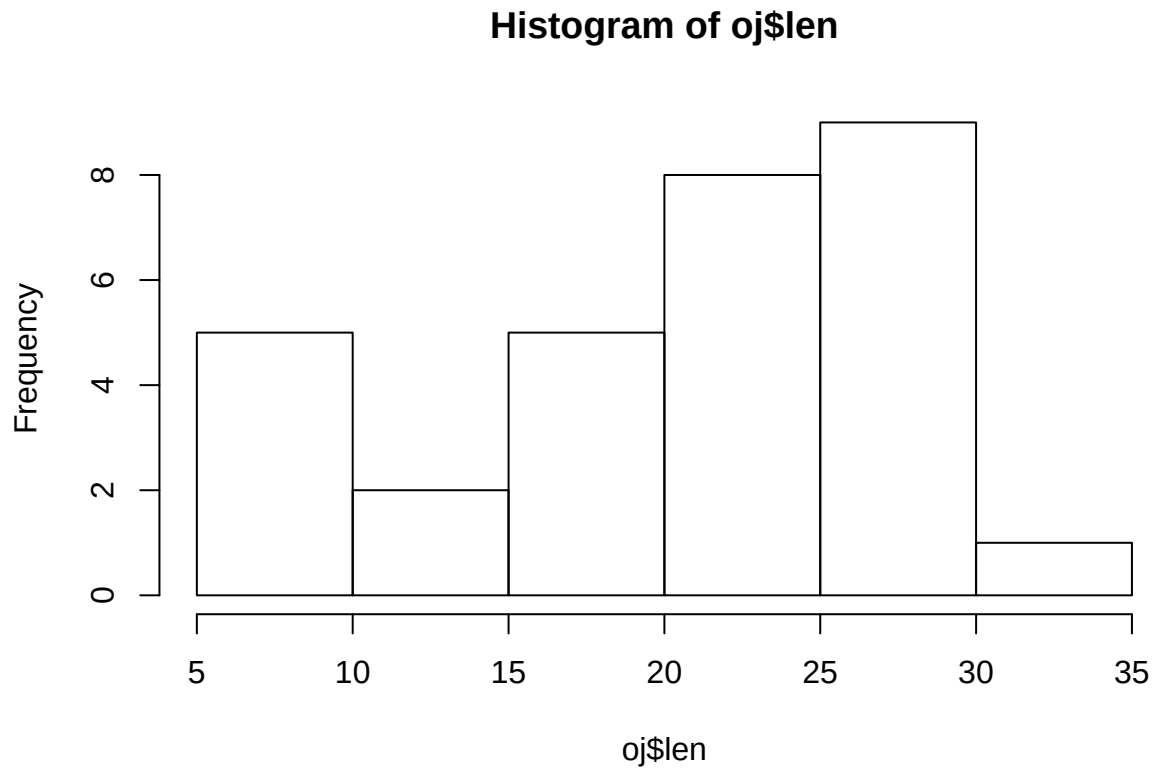
## Data summary

```r
# Summarize columns
summary(ToothGrowth)
```

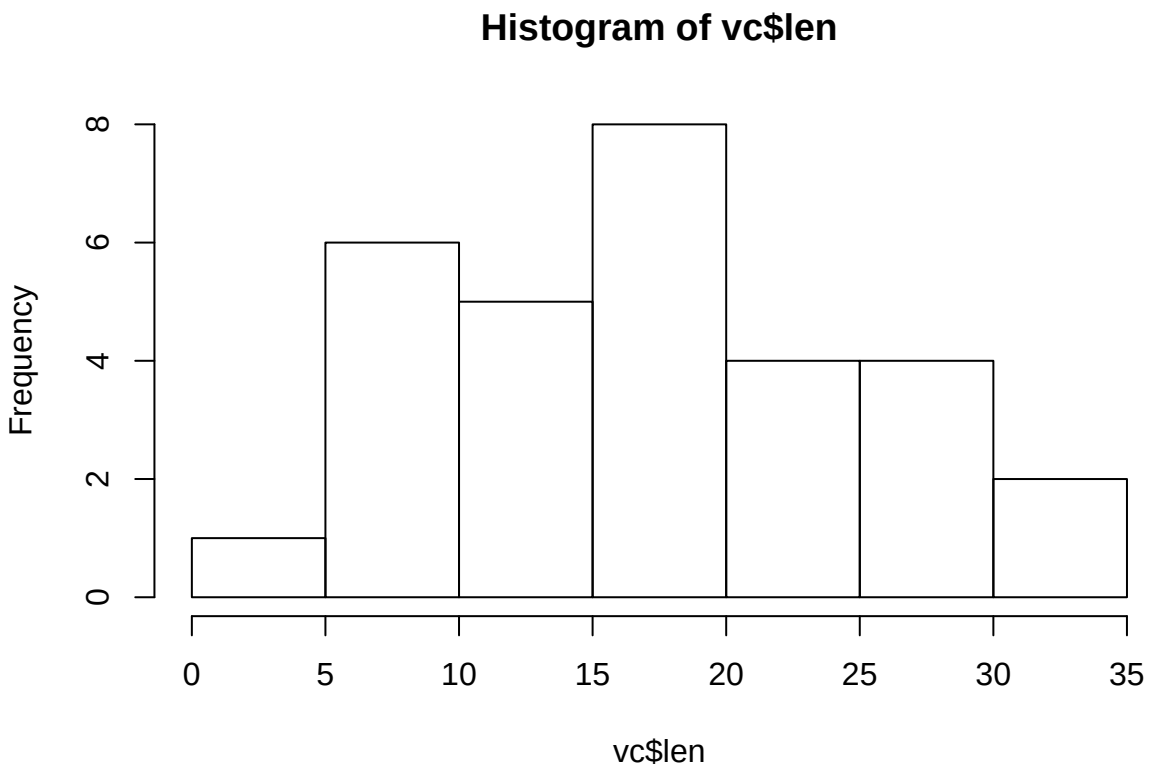
```
##       len        supp         dose
##  Min.   : 4.20   OJ:30   Min.   :0.500
##  1st Qu.:13.07   VC:30   1st Qu.:0.500
##  Median :19.25           Median :1.000
##  Mean   :18.81           Mean   :1.167
##  3rd Qu.:25.27           3rd Qu.:2.000
##  Max.   :33.90           Max.   :2.000
```

```r
# Let's look at our 30 guinea pigs given orange
# juice and ascorbic acid
oj <- ToothGrowth[ToothGrowth$supp == "OJ",]
vc <- ToothGrowth[ToothGrowth$supp == "VC",]

# A histogram of tooth odontoblast length
# appears to have a positive slope possibly
# due to increasing dosages of orange juice.
hist(oj$len)
```




```r
# The histogram of the tooth growth for guinea
# pigs given ascorbic acid looks almost normal.
hist(vc$len)
```




### Comparison of tooth growth by supp and dose

```
# So lets compare tooth growth by supplement by
# dosage levels

# Given an 0.5 milligram/day dosage, we have
# 10 samples of guinea pigs given orange juice
# and 10 samples of guinea pigs given ascorbic acid
oj05 <- ToothGrowth[ToothGrowth$dose == 0.5 & ToothGrowth$supp == "OJ",]
vc05 <- ToothGrowth[ToothGrowth$dose == 0.5 & ToothGrowth$supp == "VC",]
dim(oj05)
```

```
## [1] 10  3
```

```
dim(vc05)
```

```
## [1] 10  3
```

```
# Our means and standard error for the orange
# juice samples at the 0.5 mg/day level are:
mean(oj05$len)
```

```
## [1] 13.23
```

```
sd(oj05$len)
```

```
## [1] 4.459709
```

```r
# So we conduct a t-test on the orange
# juice sample at the 0.5 mg/day dosage level.
# This shows we can reject the null hypothesis
# that the orange juice had no impact on the
# guinea pigs' tooth growth.
t.test(oj05$len)
```

```
##
##  One Sample t-test
##
## data:  oj05$len
## t = 9.3811, df = 9, p-value = 6.074e-06
## alternative hypothesis: true mean is not equal to 0
## 95 percent confidence interval:
##  10.03972 16.42028
## sample estimates:
## mean of x
##     13.23
```

```r
# Our means and standard error for the ascorbic
# acid samples at the 0.5 mg/day level are:
mean(vc05$len)
```

```
## [1] 7.98
```

```r
sd(vc05$len)
```

```
## [1] 2.746634
```

```r
# So we conduct a t-test on the ascorbic
# acid sample at the 0.5 mg/day dosage level.
# This shows we can reject the null hypothesis
# that the ascorbic acid had no impact on the
# guinea pigs' tooth growth.
t.test(vc05$len)
```

```
##
##  One Sample t-test
##
## data:  vc05$len
## t = 9.1876, df = 9, p-value = 7.21e-06
## alternative hypothesis: true mean is not equal to 0
## 95 percent confidence interval:
##  6.015176 9.944824
## sample estimates:
## mean of x
##      7.98
```

```r
# --------------------------------

# We now compare the guinea pigs' tooth growth
# under both supplements:
# ----------------------
# At the 0.5 mg/daydosage level
tg05 <- ToothGrowth[ToothGrowth$dose == 0.5,]
t.test(len ~ supp, paired = F, var.equal = F, data = tg05)
```

```
##
##  Welch Two Sample t-test
##
## data:  len by supp
## t = 3.1697, df = 14.969, p-value = 0.006359
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  1.719057 8.780943
## sample estimates:
## mean in group OJ mean in group VC
##            13.23             7.98
```

```
# At the 1.0 mg/daydosage level
tg10 <- ToothGrowth[ToothGrowth$dose == 1.0,]
t.test(len ~ supp, paired = F, var.equal = F, data = tg10)
```

```
##
##  Welch Two Sample t-test
##
## data:  len by supp
## t = 4.0328, df = 15.358, p-value = 0.001038
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  2.802148 9.057852
## sample estimates:
## mean in group OJ mean in group VC
##            22.70            16.77
```

```
# At the 2.0 mg/daydosage level
tg20 <- ToothGrowth[ToothGrowth$dose == 2.0,]
t.test(len ~ supp, paired = F, var.equal = F, data = tg20)
```

```
##
##  Welch Two Sample t-test
##
## data:  len by supp
## t = -0.046136, df = 14.04, p-value = 0.9639
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -3.79807  3.63807
## sample estimates:
## mean in group OJ mean in group VC
##            26.06            26.14
```

```
# The power of the orange juice samples at the
# 0.5 mg/day level are:
# power.t.test(n=10,delta = 13.23,sd= 4.459709, type="one.sample", alt = "one.sided")$power
```

## Conclusions and assumptions