# The Exponential Distribution in R *versus* the Central Limit Theorem (CLT) — Part 2

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## Overview

Now in the second portion of the class, we're going to analyze the ToothGrowth data in the R datasets package.

## About the data

The response is the length of odontoblasts (cells responsible for tooth growth) in 60 guinea pigs. 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).

A data frame with 60 observations on 3 variables.

[ ,1] len numeric Tooth length
[ ,2] supp factor Supplement type (VC or OJ)
[ ,3] dose numeric Dose in milligrams/day

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

## Analysis

### 1. Load the ToothGrowth data and perform some basic exploratory data analyses

```
library(datasets)
data <- ToothGrowth
head(ToothGrowth) # Taking a look at the first parts of the dataset
```

```
##    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
```

```
str(data)  # Taking a look at how the data object is structured
```

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

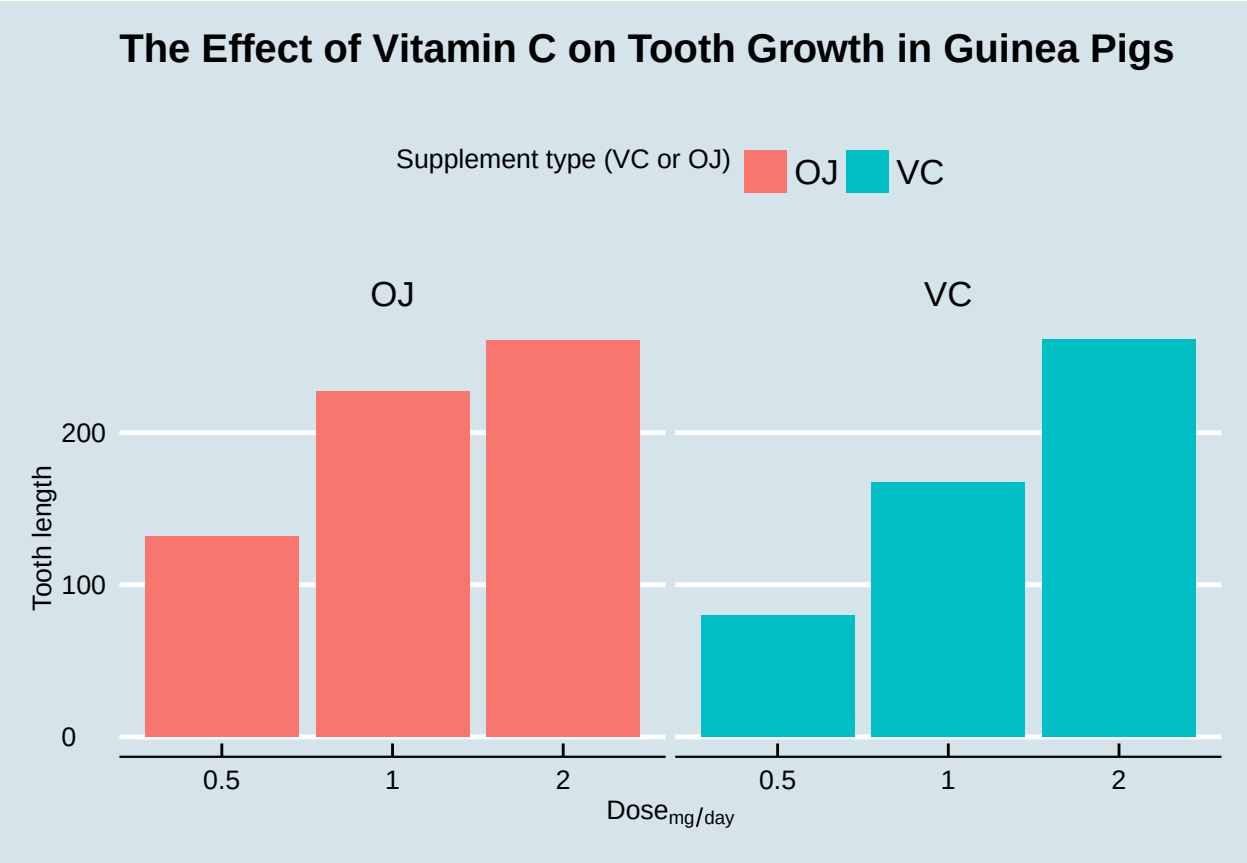
```r
data$dose <- as.factor(data$dose) # Converting dose to factor instead of numeric
```

**2. Provide a basic summary of the data**

```r
summary(data) # Summary of the dataset
```

```
##       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
```

```r
library(ggplot2)
library(ggthemes)
ggplot(data, aes(x = dose, y = len, fill = supp)) + geom_bar(stat = "identity") +
  facet_grid(. ~ supp) + labs(x = expression("Dose"[mg/day])) + ylab("Tooth length") +
  guides(fill = guide_legend(title = "Supplement type (VC or OJ)\n")) +
  ggtitle("The Effect of Vitamin C on Tooth Growth in Guinea Pigs") +
  theme_economist()
```




Observing the plot, we see that the amount of supplement (OJ or VC) given to a guinea pig seems to make their teeth grow bigger.

**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)**

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

```
##
##  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
```

$H_0$ = supplement type affects tooth growth: P-value (0.06063) is greater than 0.05, therefore we cannot reject the null hypothesis ($H_0$).

```
data <- ToothGrowth # Fetching the data again (now we need dosage as numeric)
t.test(data$len, data$dose)
```

```
##
##  Welch Two Sample t-test
##
## data:  data$len and data$dose
## t = 17.81, df = 59.798, p-value < 2.2e-16
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  15.66453 19.62881
## sample estimates:
## mean of x mean of y
## 18.813333  1.166667
```

$H_a$ = dosage affects tooth growth: P-value ($< 2.2e\text{-}16$ or $< 0.00000000000000022$) is less than 0.05, therefore we can reject the alternative hypothesis ($H_a$).

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

**Conclusions:**
**$H_0$ = supplement type affects tooth growth:** This hypothesis cannot be rejected. Which means that there is not enough evidence to affirm that the a type of supplement is better than the other.
**$H_a$ = dosage affects tooth growth:** This hypothesis can be rejected. Which means that the amount of supplement affects the tooth growth.Thus, when dosage is increased the guinea pig's tooth grows bigger.
**Assumptions:**
1. The 60 guinea pigs used is the study represent the whole population of guinea pigs;
2. Variance is different for the sample and the theoritical group.

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