Analysis of the ToothGrowth Data from R Datasets Package

Overview

This project explores the *ToothGrowth* data from the R *datasets* library by performing some preliminary analysis on the data and drawing some initial conclusions.

Exploratory Data Analysis

```
library(dplyr)       # Data manipulation (filter, mutate, group_by, etc.)
library(ggplot2)     # Plotting (qplot, ggplot etc.)
library(knitr)       # Dynamic Report Creation
library(datasets)    # R included sample data sets
data(ToothGrowth)    # Load ToothGrowth data set
```

To setup the analysis we load the required libraries and the *ToothGrowth* data set. Per the R documentation for the *datasets* package [1], *ToothGrowth* is described as follows:

> 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).

```
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 ...
```

```
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  
```

```
table(ToothGrowth$supp)
```

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

```
table(ToothGrowth$dose)
```

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

```
table(ToothGrowth %>% select(supp, dose))
```

```
##     dose
## supp 0.5  1  2
##   OJ  10 10 10
##   VC  10 10 10
```

The exploratory analysis of the *ToothGrowth* data frame demonstrates that the data consist of 30 observations each of *supp OJ* (Orange Juice) and *VC* (Ascorbic Acid); the 30 observations of each *supp* consist of 10 observations each of the three *dose* levels (0.5, 1 and 2).

Data Summary

```
tgBySuppDose <- ToothGrowth %>%
    group_by(Suppliment = supp, Dose = dose) %>%
    summarize(
        Length = mean(len)
        ,CI = 2 * sd(len) / sqrt(n())
    ) %>%
    arrange(Suppliment, Dose, desc(Length))

kable(tgBySuppDose
      ,format = "markdown"
      ,caption = "ToothGrowth by Suppliment and Dose"
)
```

Suppliment	Dose	Length	CI
OJ	0.5	13.23	2.820567
OJ	1.0	22.70	2.473504
OJ	2.0	26.06	1.679206
VC	0.5	7.98	1.737124
VC	1.0	16.77	1.590821
VC	2.0	26.14	3.034352

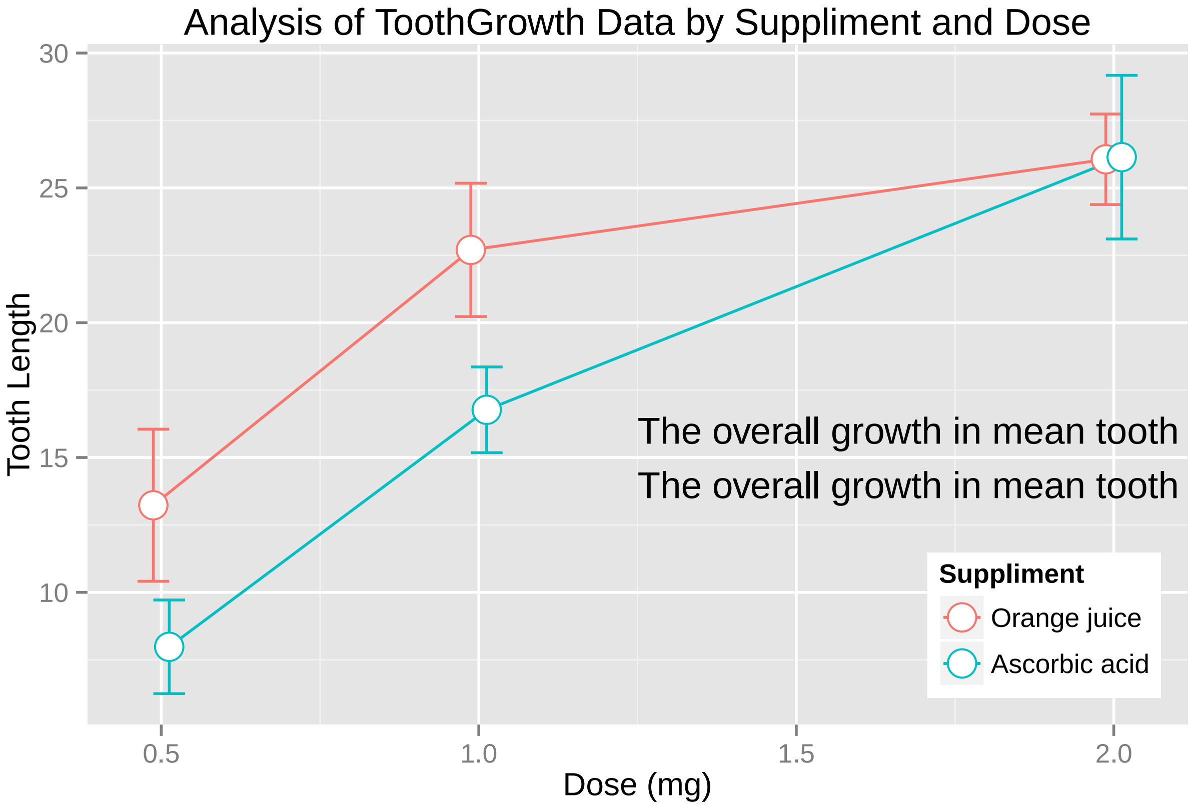
To summarize the data we create a data frame grouped by *Suppliment* and *Dose*. Derived summary data for each group include the mean length (*Length*) and the 95% confidence interval (*CI*). The confidence interval is derived by multiplying the standard deviation (σ) by two and dividing by the square root of the number of observations (n), i.e.: $2\sigma/\sqrt{n}$.

Confidence Intervals and Hypothesis Test

```
pd <- position_dodge(0.05)
plot1 <- ggplot(
    tgBySuppDose
    ,aes(
        x = Dose
        ,y = Length
        ,ymax = max(Length)
        ,color = Suppliment
    )

) + geom_errorbar(
    aes(
        ymin = Length - CI
        ,ymax = Length + CI

    )
    ,width = .1
    ,position = pd
) + geom_line(
    position = pd
) + geom_point(
    position = pd
    , size = 5
    , shape=21
    , fill = "white"
) + labs(
    title = "Analysis of ToothGrowth Data by Suppliment and Dose"
    ,x = "Dose (mg)"
    ,y = "Tooth Length"
) + scale_colour_hue(
    breaks=c("OJ", "VC")
    ,labels=c("Orange juice", "Ascorbic acid")
) + theme(
    legend.justification=c(1,0)
    ,legend.position=c(1,0)
) + annotate(
    "text"
    ,x = 1.25
    ,y = 15
    ,label =
        paste(
            "The overall growth in mean tooth length using orange juice is"
            ,diff(range((tgBySuppDose %>% filter(Suppliment == "OJ"))$Length))
            ,"\nThe overall growth in mean tooth length using ascorbic acid is"
            ,diff(range((tgBySuppDose %>% filter(Suppliment == "VC"))$Length))
        )
    ,size = 5
    ,hjust = 0
)
print(plot1)
```



Based on a visualization of the summarized data we find that in general increasing the dosage of Vitamin C leads to an increase in the mean of tooth length via both delivery methods (orange juice and ascorbic acid). While the

highest supplied dosage (2.0 mg) of each method produce similar means (26.06 and 26.14, respectively), the 95% confidence interval for orange juice is ~ 44% smaller than that of ascorbic acid (± ~1.68 vs. 3.03, respectively) whereas the overall growth in the mean for ascorbic acid is higher (12.83 to 18.16, respectively).

Conclusions

The analysis suggests that increasing dosage of Vitamin C to 2.0 mg yields increases in mean tooth length for both delivery methods. While the overall growth in the mean is higher for ascorbic acid than for orange juice, means at 2.0 mg dosage are similar with a tighter confidence interval for delivery via orange juice and yield higher means at 0.5 and 1.0 mg dosages, suggesting that orange juice is a more effective delivery method.

Reference

[1] https://stat.ethz.ch/R-manual/R-devel/library/datasets/html/ToothGrowth.html