An Analysis of the Effect of Vitamin C on Tooth Growth in Guinea Pigs

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Overview

This analysis examines the effect of vitamin C dosage and delievery method on the length of odontoblast cells in 60 guinea pigs from the ToothGrowth dataset supplied by R. Here we examined the effect of increasing dosages of vitamin C on cell length and found that larger dosages (up to 2.0 mg/day) correspond with significantly greater mean cell length. We also examined the effect of delivery method (orange juice vs. ascorbic acid) on mean cell length and found a significantly greater mean length for guinea pigs receiving vitamin C via orange juice.

Data Summary

The data for this analysis comes from the ToothGrowth dataset preloaded into R. There are 60 observations in this data where each observation includes the vitamin C dosage, delivery method (one of orange juice (OJ) or ascorbic acid (VC)), and the length of the odontoblast cells responsible for tooth growth in guinea pigs. Each animal received a particular dosage (0.5, 1, or 2 mg/day) of vitamin C through one of the two specified delivery methods. At the end of the period their ondontoblast cell lengths were observed and recorded.

The data is formatted as follows:

```
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
```

Analysis

Data Exploration

We begin our analysis with a quick look at the data. First, we look at the mean length of the cells by delivery method.

```
aggregate(len ~ supp, data = ToothGrowth, FUN = mean)
```

```
##   supp      len
## 1   OJ 20.66333
## 2   VC 16.96333
```

It appears that delivering the vitamin C dosages via OJ may correspond with greater cell length independent of dosage level.

Lets also look at mean cell length by dose, regardless of delivery method.

```
aggregate(len ~ dose, data = ToothGrowth, FUN = mean)
```

```
##   dose    len
## 1  0.5 10.605
## 2  1.0 19.735
## 3  2.0 26.100
```

It also appears that increasing the dosage of vitamin C may lead to longer cells as well.

Finally, we look at mean cell length by both delivery method and dosage.

```
aggregate(len ~ ., data = ToothGrowth, FUN = mean)
```

```
##   supp dose   len
## 1   OJ  0.5 13.23
## 2   VC  0.5  7.98
## 3   OJ  1.0 22.70
## 4   VC  1.0 16.77
## 5   OJ  2.0 26.06
## 6   VC  2.0 26.14
```

Somewhat confirming our suspicions above, it looks like OJ may lead to longer cells than VC and increasing dosage levels of vitamin C may also lead to longer cells. Of note is the observation that at a dosage level of 2.0, it appears that it may not make a difference which delivery method was used.

Of course, our suspicions should be validated with some statistical analysis, which we will now perform.

Statistical Analysis

For all of our statistical analysis we will make the assumption that our data is iid and normally distributed. Since we have a small sample size, 60, we will use Students T tests during our analysis.

First, we will consider the possibility that delivering the vitamin C via OJ yields longer cells than delivering via VC. We let our null hypothesis be that there is no significant difference, and let the alternative hypothesis be that mean length is greater via OJ than with VC.

```
result <- t.test(length.oj, length.vc, alternative = 'greater')
result$conf.int
```

```
## [1] 0.4682687       Inf
## attr(,"conf.level")
## [1] 0.95
```

```
result$p.value
```

```
## [1] 0.03031725
```

We can see that the p-value for our above test is approximately 0.03 and is less than a significance level of 0.05.

Next, we will consider the possibility that increasing dosages of vitamin C yield longer cells. Here we will have to make a few different comparisons. In particular, we will look at difference is cell length between dosages of 0.5 and 1.0, and 1.0 and 2.0. In each case, the null hypothesis is that there is no difference in mean cell length and the alternative is that the higher dose has a significantly greater mean cell length.

```
# 0.5 vs 1.0
result <- t.test(length.1.0, length.0.5, alternative = 'greater')
result$conf.int
```

```
## [1] 6.753323      Inf
## attr(,"conf.level")
## [1] 0.95
```

```
format(result$p.value, scientific = FALSE)
```

```
## [1] "0.00000006341504"
```

We can see that the p-value of this test is much smaller than a significance level of 0.05.

```
# 1.0 vs 2.0
result <- t.test(length.2.0, length.1.0, alternative = 'greater')
result$conf.int
```

```
## [1] 4.17387     Inf
## attr(,"conf.level")
## [1] 0.95
```

```
format(result$p.value, scientific = FALSE)
```

```
## [1] "0.000009532148"
```

The same can be said of this p-value.

Conclusions

In all of our tests, the p-values we obtained indicate that we can safely reject the null hypothesis and accept the alternative. This is of course conditioned on our assumptions of iid and normally distributed data. Thus, we can make the following conclusions.

1. Delivering vitamin C to guinea pigs via orange juice leads to longer odontoblast cell length.
2. Increasing dosages from 0.5 to 1.0 and from 1.0 to 2.0 leads to longer odontoblast cell length.

A possible limitation of this analysis are that the beginning length of the cells was not available. This could mean that each guinea pig began the study with different cell lengths which would pollute the final cell length observation unless accounted for.