Demonstrating Approximate Normality

To show the distribution of sample means is approximately normal, we overlay a normal curve on the histogram and create a Q-Q plot.

Histogram with normal curve

hist(means, probability = TRUE, main = “Histogram with Normal Curve”, col = “lightblue”, xlab = “Sample Mean”) curve(dnorm(x, mean = mean(means), sd = sd(means)), col = “red”, lwd = 2, add = TRUE)

Q-Q plot

qqnorm(means) qqline(means, col = “red”, lwd = 2)

```
## ToothGrowth Data Analysis
We now perform basic inferential analysis using the ‘ToothGrowth‘ dataset available in R.
We explore the effect of supplement type and dose on tooth length.


‘‘‘ r
data("ToothGrowth")
ToothGrowth$dose <- as.factor(ToothGrowth$dose)

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
```

```
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
```

Exploratory Boxplot

library(ggplot2) ggplot(ToothGrowth, aes(x = dose, y = len, fill = supp)) + geom_boxplot() + labs(title = “Tooth Length by Supplement Type and Dose”, x = “Dose (mg/day)”, y = “Tooth Length”) + theme_minimal() # T-test: Supplement type comparison t.test(len ~ supp, data = ToothGrowth, var.equal = TRUE)

T-test: Dose comparisons

0.5 vs 1

t.test(len ~ dose, data = subset(ToothGrowth, dose %in% c("0.5", "1")))

1 vs 2

t.test(len ~ dose, data = subset(ToothGrowth, dose %in% c("1", "2")))

0.5 vs 2

t.test(len ~ dose, data = subset(ToothGrowth, dose %in% c("0.5", "2")))

Sample Variance vs Theoretical Variance

We now compare the sample variance of the means to the theoretical variance of the sampling distribution of the mean. The theoretical variance is calculated as `(1 / lambda)^2 / n`.

```
# Calculate sample and theoretical variance
sample_variance <- var(means)
theoretical_variance <- (1 / lambda)^2 / n  # Variance of the sample mean

# Output both values
sample_variance
```

```
## [1] 0.5706551
```

```
theoretical_variance
```

```
## [1] 0.625
```

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hist(means, probability = TRUE, main = "Histogram with Normal Curve", col = "lightblue", xlab = "Sample Mean") curve(dnorm(x, mean = mean(means), sd = sd(means)), col = "red", lwd = 2, add = TRUE)

Q-Q plot

qqnorm(means) qqline(means, col = “red”, lwd = 2)

```
## ToothGrowth Data Analysis
We now perform basic inferential analysis using the ‘ToothGrowth‘ dataset available in R.  We explore t
```

‘‘‘ r

```
# Load the dataset and prepare it
data("ToothGrowth")
ToothGrowth$dose <- as.factor(ToothGrowth$dose)

# View dataset structure
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
```

```
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
```

Exploratory Plot

We create a boxplot to visualize the effect of supplement type and dose on tooth length.

library(ggplot2) ggplot(ToothGrowth, aes(x = dose, y = len, fill = supp)) + geom_boxplot() + labs(title = “Tooth Length by Supplement Type and Dose”, x = “Dose (mg/day)”, y = “Tooth Length”) + theme_minimal() # Hypothesis Tests We compare tooth length by supplement type and between dose levels using t-tests.

Supplement type comparison

t.test(len ~ supp, data = ToothGrowth, var.equal = TRUE)

Dose level comparisons

t.test(len ~ dose, data = subset(ToothGrowth, dose %in% c("0.5", "1"))) t.test(len ~ dose, data = subset(ToothGrowth, dose %in% c("1", "2"))) t.test(len ~ dose, data = subset(ToothGrowth, dose %in% c("0.5", "2"))) "'