The Effect of Lunar Phases on Mental Health Admissions

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Abstract

For centuries, the full moon has been associated with unusual human behavior, from folklore about werewolves to claims of increased crime rates. This study examines whether the full moon affects mental health by analyzing 12 months of admissions data from a mental health facility. The data is structured to compare admission rates before, during, and after the full moon, while also accounting for seasonal variations.

Purpose

This study aims to determine whether hospital admissions for mental health crises are influenced by the lunar cycle. Specifically, we analyze admission rates before, during, and after a full moon to assess potential patterns.

Questions to be addressed:

- Are hospital admissions associated with the lunar phase?
- Are hospital admissions independent of the lunar phase when accounting for seasonal differences?
- Does the relationship between lunar phase and hospital admissions depend on the season?

Background

- **Sample:** 36 observations collected over 12 months, with three lunar-phase periods per month (before, during, and after the full moon).
- **Population of Interest:** Patients admitted to the mental health facility.
- **Relevant Variables:**
  - **Lunar phase** (categorical: before, during, after full moon)
  - **Month** (categorical: January, February, . . . , December)
  - **Hospital admissions** (numerical: number of patients per period)

Exploratory Data Analysis

Month	Moon	Admission
Aug	Before	6.4
Sep	Before	7.1
Oct	Before	6.5
Nov	Before	8.6
Dec	Before	8.1
Jan	Before	10.4

Now we will break this sample down according to lunar phase(`Moon`)

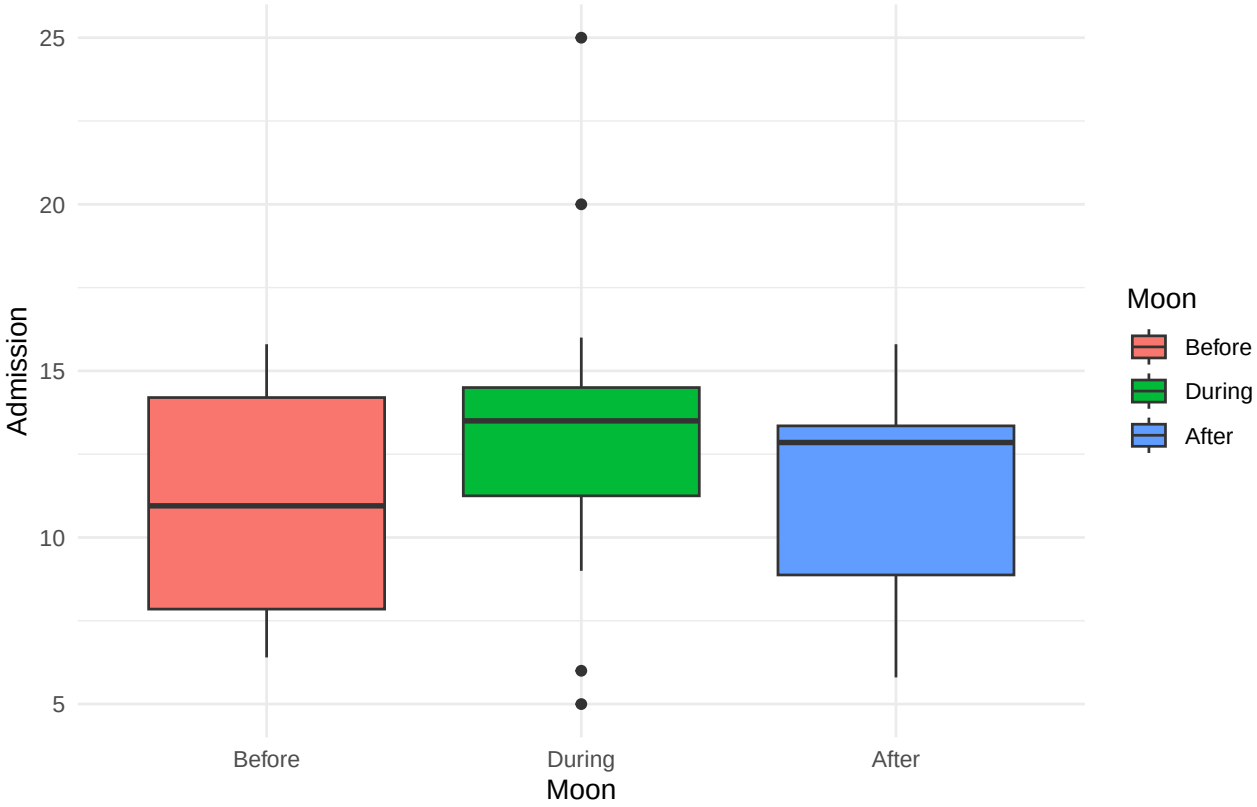

Figure 1: Mental Health Admissions by Lunar Phase

There doesn't appear to be very much between-group variance, but within-group variance is prominent among admissions during a full-moon.

We will proceed by segmenting the sample by month, and displaying the resulting boxplot (Figure 2).

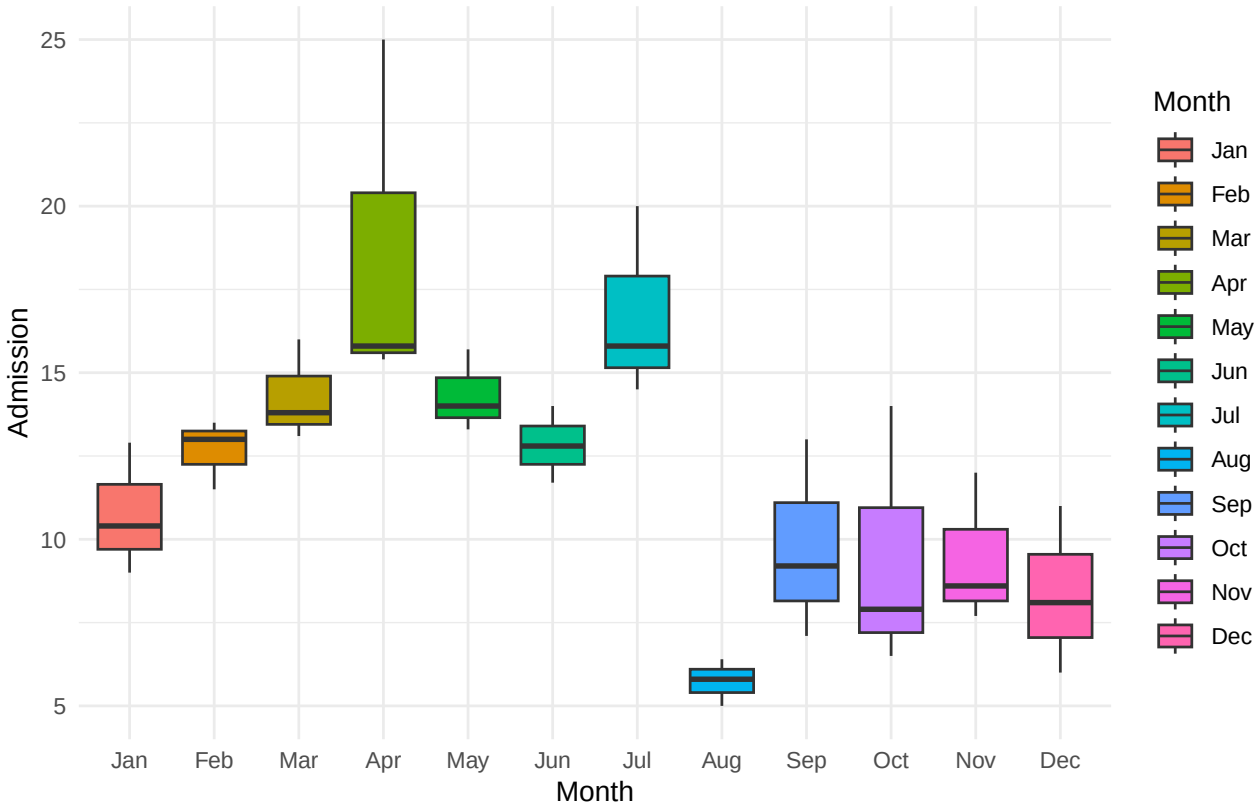

Figure 2: Mental Health Admissions by Month

Within-group variance varies quite significantly, as does between-group variance. This is particularly noticeable between the months of July and August. Additionally, a seasonal pattern appears to emerge when breaking the sample down by `Month`.

We will crease a `season` variable to observe the seasonal trend from a more compact timescale than when viewing admissions on a monthly basis. This information can be displayed succinctly within a two-way contingency table.

```
##         Moon
## Season   Before During After
##   Fall     22.2   39.0  24.8
##   Spring   44.9   55.0  42.2
##   Summer   33.9   39.0  33.1
##   Winter   30.0   28.0  37.4
```

We can procceed with plotting this data (Figure 3):

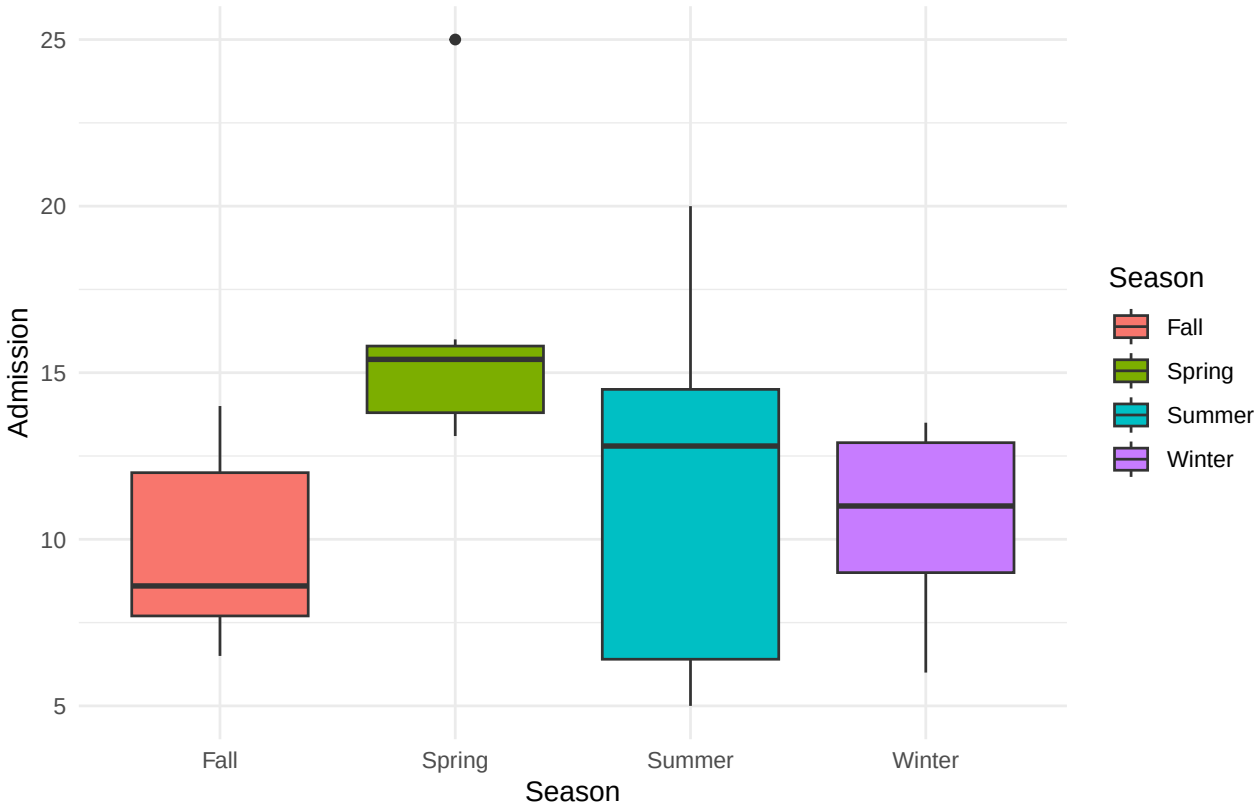

Figure 3: Mental Health Admissions by Season

The resulting boxplot appears to confirm our previous observation of a seasonal trend. This is especially noticable when observing the difference between the Fall and Spring data.

The within-group variance appears to be significantly different in the Summer. We will test this further using the levene test before proceeding with a model.

We can visually assess egregious departures from normality by observing the distribution of the data on a seasonal basis using histograms (Figure 4):

Season	Observation Count
Fall	9
Spring	9
Summer	9
Winter	9

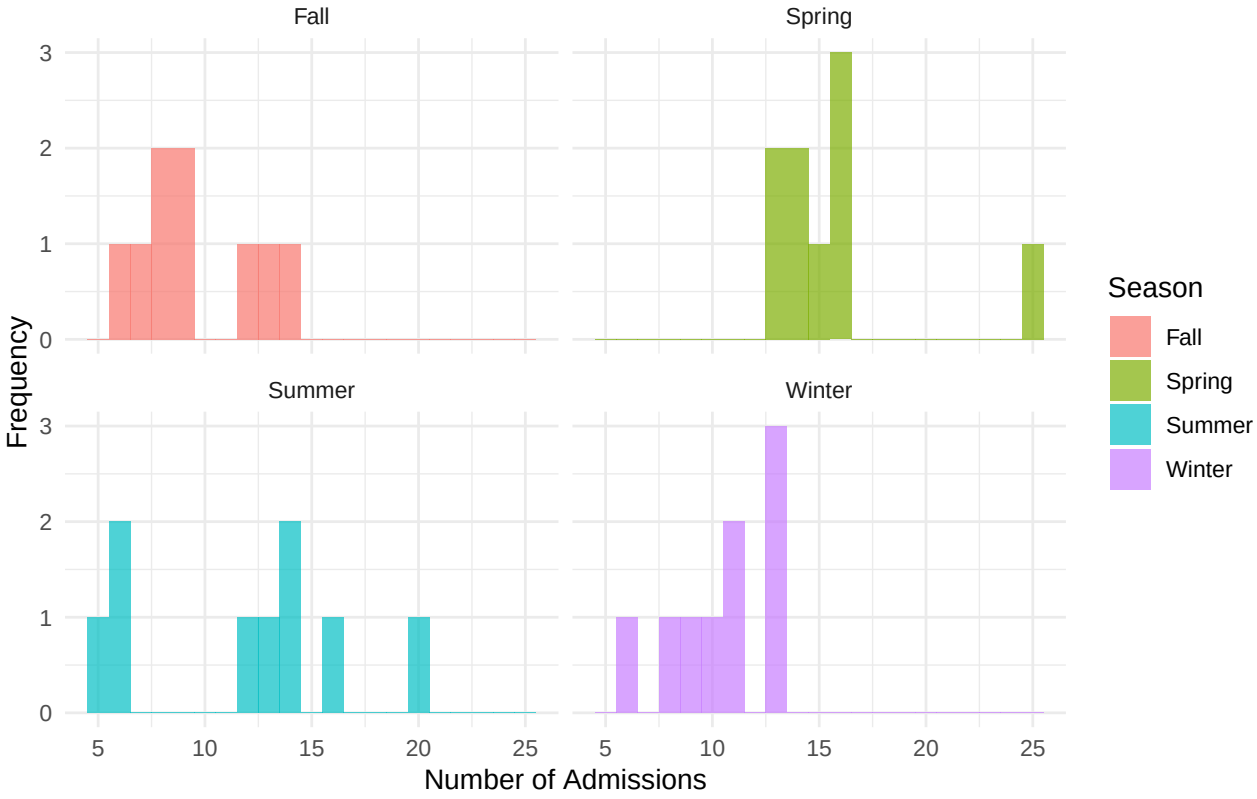

Figure 4: Distribution of Admissions by Season

The histograms appear to be normal enough for our purposes, it is difficult to detect non-normality given the small sample sizes present in the histograms ($n = 9$ per plot).

Model Selection and Analysis

ANOVA

Three main assumptions must be met before proceeding with a one-way ANOVA test: 1. Responses for each factor must come from an approximately normal distribution 2. Each distribution must have approximately equal variance 3. The data must be independent

	Df	F value	Pr(>F)
group	11	1.07637	0.4185177
	24	NA	NA

The homogeneity assumption of the variance is met through the Levene test.

```
##             Df Sum Sq Mean Sq F value  Pr(>F)
## Moon         2  41.51   20.76   1.577 0.22735
## Season       3 200.89   66.96   5.086 0.00724 **
## Moon:Season  6  66.53   11.09   0.842 0.55002
## Residuals   24 315.99   13.17
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

According to the ANOVA table, the Season seems to have the greatest effect on admissions.

Assumptions required for Tukey's Honest Significant Difference Test (Tukey's HSD):

1. Independent Observations
2. Normality
3. Homogeneity of Variance (between-group variance approximately equal)
4. Random Sampling

The independence of the observations and their random sampling are taken for granted based on the description of the study provided. Someone's admission into a mental hospital should not alter the mental health of the population enough to contradict the assumption of independence. The members of the population that arrive at a mental health facility should be random enough for condition 4 to be met.

```
##
##  Shapiro-Wilk normality test
##
## data:  residuals(anova_model)
## W = 0.95438, p-value = 0.1436
```

The assumption of the normality of the residuals is met through the Shapiro-Wilk test.

```
##   Tukey multiple comparisons of means
##     95% family-wise confidence level
##
## Fit: aov(formula = Admission ~ Moon * Season, data = MentalHealth)
##
## $Moon
##                     diff       lwr      upr     p adj
```

```
## During-Before  2.5000000 -1.199318 6.199318 0.2303834
## After-Before   0.5416667 -3.157651 4.240984 0.9291646
## After-During  -1.9583333 -5.657651 1.740984 0.3970873
##
## $Season
##                    diff       lwr        upr     p adj
## Spring-Fall    6.233333  1.514739 10.9519274 0.0065914
## Summer-Fall    2.222222 -2.496372  6.9408163 0.5723088
## Winter-Fall    1.044444 -3.674150  5.7630385 0.9277072
## Summer-Spring -4.011111 -8.729705  0.7074829 0.1157989
## Winter-Spring -5.188889 -9.907483 -0.4702948 0.0273852
## Winter-Summer -1.177778 -5.896372  3.5408163 0.9004473
##
## $`Moon:Season`
##                                        diff         lwr       upr     p adj
## During:Fall-Before:Fall       5.600000e+00  -5.0822859 16.282286 0.7540075
## After:Fall-Before:Fall        8.666667e-01  -9.8156192 11.548953 1.0000000
## Before:Spring-Before:Fall     7.566667e+00  -3.1156192 18.248953 0.3558309
## During:Spring-Before:Fall     1.093333e+01   0.2510474 21.615619 0.0416026
## After:Spring-Before:Fall      6.666667e+00  -4.0156192 17.348953 0.5329890
## Before:Summer-Before:Fall     3.900000e+00  -6.7822859 14.582286 0.9685406
## During:Summer-Before:Fall     5.600000e+00  -5.0822859 16.282286 0.7540075
## After:Summer-Before:Fall      3.633333e+00  -7.0489526 14.315619 0.9810148
## Before:Winter-Before:Fall     2.600000e+00  -8.0822859 13.282286 0.9987694
## During:Winter-Before:Fall     1.933333e+00  -8.7489526 12.615619 0.9999233
## After:Winter-Before:Fall      5.066667e+00  -5.6156192 15.748953 0.8468816
## After:Fall-During:Fall       -4.733333e+00 -15.4156192  5.948953 0.8937456
## Before:Spring-During:Fall     1.966667e+00  -8.7156192 12.648953 0.9999094
## During:Spring-During:Fall     5.333333e+00  -5.3489526 16.015619 0.8028935
## After:Spring-During:Fall      1.066667e+00  -9.6156192 11.748953 0.9999998
## Before:Summer-During:Fall    -1.700000e+00 -12.3822859  8.982286 0.9999786
## During:Summer-During:Fall    -1.776357e-15 -10.6822859 10.682286 1.0000000
## After:Summer-During:Fall     -1.966667e+00 -12.6489526  8.715619 0.9999094
## Before:Winter-During:Fall    -3.000000e+00 -13.6822859  7.682286 0.9957760
## During:Winter-During:Fall    -3.666667e+00 -14.3489526  7.015619 0.9797038
## After:Winter-During:Fall     -5.333333e-01 -11.2156192 10.148953 1.0000000
## Before:Spring-After:Fall      6.700000e+00  -3.9822859 17.382286 0.5259799
## During:Spring-After:Fall      1.006667e+01  -0.6156192 20.748953 0.0775290
## After:Spring-After:Fall       5.800000e+00  -4.8822859 16.482286 0.7147766
## Before:Summer-After:Fall      3.033333e+00  -7.6489526 13.715619 0.9953708
## During:Summer-After:Fall      4.733333e+00  -5.9489526 15.415619 0.8937456
## After:Summer-After:Fall       2.766667e+00  -7.9156192 13.448953 0.9978762
## Before:Winter-After:Fall      1.733333e+00  -8.9489526 12.415619 0.9999740
## During:Winter-After:Fall      1.066667e+00  -9.6156192 11.748953 0.9999998
## After:Winter-After:Fall       4.200000e+00  -6.4822859 14.882286 0.9483725
## During:Spring-Before:Spring   3.366667e+00  -7.3156192 14.048953 0.9893223
## After:Spring-Before:Spring   -9.000000e-01 -11.5822859  9.782286 1.0000000
## Before:Summer-Before:Spring -3.666667e+00 -14.3489526  7.015619 0.9797038
## During:Summer-Before:Spring -1.966667e+00 -12.6489526  8.715619 0.9999094
## After:Summer-Before:Spring  -3.933333e+00 -14.6156192  6.748953 0.9666403
## Before:Winter-Before:Spring -4.966667e+00 -15.6489526  5.715619 0.8619348
## During:Winter-Before:Spring -5.633333e+00 -16.3156192  5.048953 0.7476045
## After:Winter-Before:Spring  -2.500000e+00 -13.1822859  8.182286 0.9991344
## After:Spring-During:Spring  -4.266667e+00 -14.9489526  6.415619 0.9429040
```

```
## Before:Summer-During:Spring -7.033333e+00 -17.7156192  3.648953 0.4573060
## During:Summer-During:Spring -5.333333e+00 -16.0156192  5.348953 0.8028935
## After:Summer-During:Spring  -7.300000e+00 -17.9822859  3.382286 0.4050090
## Before:Winter-During:Spring -8.333333e+00 -19.0156192  2.348953 0.2354753
## During:Winter-During:Spring -9.000000e+00 -19.6822859  1.682286 0.1575570
## After:Winter-During:Spring  -5.866667e+00 -16.5489526  4.815619 0.7013119
## Before:Summer-After:Spring  -2.766667e+00 -13.4489526  7.915619 0.9978762
## During:Summer-After:Spring  -1.066667e+00 -11.7489526  9.615619 0.9999998
## After:Summer-After:Spring   -3.033333e+00 -13.7156192  7.648953 0.9953708
## Before:Winter-After:Spring  -4.066667e+00 -14.7489526  6.615619 0.9582071
## During:Winter-After:Spring  -4.733333e+00 -15.4156192  5.948953 0.8937456
## After:Winter-After:Spring   -1.600000e+00 -12.2822859  9.082286 0.9999884
## During:Summer-Before:Summer  1.700000e+00  -8.9822859 12.382286 0.9999786
## After:Summer-Before:Summer  -2.666667e-01 -10.9489526 10.415619 1.0000000
## Before:Winter-Before:Summer -1.300000e+00 -11.9822859  9.382286 0.9999986
## During:Winter-Before:Summer -1.966667e+00 -12.6489526  8.715619 0.9999094
## After:Winter-Before:Summer   1.166667e+00  -9.5156192 11.848953 0.9999996
## After:Summer-During:Summer  -1.966667e+00 -12.6489526  8.715619 0.9999094
## Before:Winter-During:Summer -3.000000e+00 -13.6822859  7.682286 0.9957760
## During:Winter-During:Summer -3.666667e+00 -14.3489526  7.015619 0.9797038
## After:Winter-During:Summer  -5.333333e-01 -11.2156192 10.148953 1.0000000
## Before:Winter-After:Summer  -1.033333e+00 -11.7156192  9.648953 0.9999999
## During:Winter-After:Summer  -1.700000e+00 -12.3822859  8.982286 0.9999786
## After:Winter-After:Summer    1.433333e+00  -9.2489526 12.115619 0.9999962
## During:Winter-Before:Winter -6.666667e-01 -11.3489526 10.015619 1.0000000
## After:Winter-Before:Winter   2.466667e+00  -8.2156192 13.148953 0.9992335
## After:Winter-During:Winter   3.133333e+00  -7.5489526 13.815619 0.9939621
```

None of the interaction terms appeared to have made a significant impact on the admission rates. The only variable pairings that meet a significance threshold of $\alpha \leq 0.05$ are in the `Season` category.

Notable results: -Spring-Fall ($p = 0.0065914$) -Winter-Spring ($p = 0.0273852$)

We can supplement this finding by conducting a t-test between the significant variable pairs.

```
##
##  Two Sample t-test
##
## data:  Admission by Season
## t = -4.1075, df = 16, p-value = 0.0008235
## alternative hypothesis: true difference in means between group Fall and group Spring is not equal to
## 95 percent confidence interval:
##  -9.450378 -3.016289
## sample estimates:
##   mean in group Fall mean in group Spring
##             9.555556            15.788889
```

```
##
##  Two Sample t-test
##
## data:  Admission by Season
## t = 3.5244, df = 16, p-value = 0.002815
## alternative hypothesis: true difference in means between group Spring and group Winter is not equal t
## 95 percent confidence interval:
```

```
##  2.067784 8.309994
## sample estimates:
## mean in group Spring mean in group Winter
##             15.78889             10.60000
```

The t-tests reinforce what was found in the TukeyHSD.

Conclusion

We found that `season` was the most significant predictor of hospital admissions, with lunar phase failing to meet our significance threshold. More specifically, there seems to be a significant increase in admissions between the Fall and Spring months and between the Winter and Spring months. The overall trend suggests that admissions to mental health facilities tend to fall during the Fall and Winter, while rising dramatically in the Spring.

Limitations

The study is limited by the relatively low sample size when considering the segmentation of the data that took place when placing it into a contingency table. This makes detecting departures from normality more difficult. A future study may aggregate data from multiple hospital locations, perhaps with varying climates, to see if the association with season and Admissions is spurious and simply a consequence of temperatures restraining activities and thus the potential for mental health breakdowns. Since this dataset comes from a single mental hospital, it may not adequately represent the human population. Culture may also alter perceptions held regarding the full moon and consequently affect the number of mental patients in a given region; this effect may be studied in further detail by replicating this study across disparate cultural regions.

Appendix: All code for this report

```
# limiting figure size and preventing code from appearing outside appendix.
knitr::opts_chunk$set(echo = FALSE, fig.width=7)
library(tidyverse)
library(car)
# load dataset...

MentalHealth <- read_csv("MentalHealth.csv", show_col_types = FALSE)

# defining the month order
month_order <- c("Jan", "Feb", "Mar", "Apr", "May", "Jun",
                 "Jul", "Aug", "Sep", "Oct", "Nov", "Dec")
# defining the lunar order
moon_order <- c("Before", "During", "After")

# converting month and moon columns to factors with specified levels
MentalHealth <- MentalHealth %>%
  mutate(Moon = factor(Moon, levels = moon_order),
         Month = factor(Month, levels = month_order))

# only displaying the first few rows of data...
head(MentalHealth)

# grouping by lunar phase
ggplot(MentalHealth, aes(x = Moon, y = Admission, fill = Moon)) +
  geom_boxplot() +
  theme_minimal()
# grouping by month
ggplot(MentalHealth, aes(x = Month, y = Admission, fill = Month)) +
  geom_boxplot() +
  theme_minimal()
MentalHealth <- MentalHealth %>%
  mutate(Season = case_when(
    Month %in% c("Dec", "Jan", "Feb") ~ "Winter",
    Month %in% c("Mar", "Apr", "May") ~ "Spring",
    Month %in% c("Jun", "Jul", "Aug") ~ "Summer",
    Month %in% c("Sep", "Oct", "Nov") ~ "Fall"))


# Sum admissions by Month and Moon Phase
#contingency_table1 <- xtabs(Admission ~ Month + Moon, data = MentalHealth)
contingency_table <- xtabs(Admission ~ Season + Moon, data = MentalHealth)

# Print the contingency table
#print(contingency_table1)
print(contingency_table)

# grouping by season
ggplot(MentalHealth, aes(x = Season, y = Admission, fill = Season)) +
  geom_boxplot() +
  theme_minimal()
# Load necessary library
```

```r
#library(ggplot2)

# check number of observations per season
MentalHealth %>% group_by(Season) %>%  summarize("Observation Count" = n())

# Create histograms for each season
ggplot(MentalHealth, aes(x = Admission, fill = Season)) +
  geom_histogram(binwidth = 1, alpha = 0.7) +
  facet_wrap(~ Season) +
  labs(x = "Number of Admissions",
       y = "Frequency") +
  theme_minimal()

# checking homogeneity of variance
leveneTest(Admission ~ Moon * Season, data = MentalHealth)
# starting with ANOVA
anova_model <- aov(Admission ~ Moon * Season, data = MentalHealth)
summary(anova_model)
# checking normality of residuals in anova
shapiro.test(residuals(anova_model))  # Shapiro-Wilk test
#
TukeyHSD(anova_model)
# testing difference in means between two most starkly different variables.

# testing difference between Fall and Spring
t.test(Admission ~ Season,
       data = subset(MentalHealth, Season %in% c("Fall", "Spring")),
       var.equal = TRUE)

# testing difference between Winter and Spring
t.test(Admission ~ Season,
       data = subset(MentalHealth,Season %in% c("Winter", "Spring")),
       var.equal = TRUE)
```