Math 247 Final Project Report

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Introduction

In this study, I aim to answer the question: "Is there a difference in the average hours of sleep per night between men and women on The Islands?" This question focuses on understanding if sex plays a role in how long people sleep. I am specifically looking at the average sleep duration for men and women.

The main idea I want to explore is whether there's a significant difference in sleep patterns between men and women. This is based on some previous research that suggests there could be differences. For example, the article "Exploring Sex and Gender Differences in Sleep Health" by Mallampalli and Carter (2014) talks about how sleep patterns might vary between genders due to biological and social reasons. The population of interest is the university students of the virtual community The Islanders, and the parameter or interest is the average hours of sleep Islanders got the night before.

Before looking at any data, I thought there might be some differences in sleep hours between men and women. This was just a guess based on general ideas about how men and women might have different health and lifestyle factors affecting their sleep. However, this study is really about looking at the data and seeing if this guess holds true or not. To start this study, I want to lay out the null hypothesis and the alternative hypothesis. The null hypothesis (H_0) states that there is no difference in the average hours of sleep between women and men. The alternative hypothesis (H_A), on the other hand states that there is a difference in the average hours of sleep between men and women on the Islands. I expect the means to be different, with no particular speculation which is higher. Though some studies in the field suggest that women might have a slightly higher average sleep duration compared to men. Therefore, both hypotheses in appropriate mathematical notation are:

$$H_0 : \mu_{male} - \mu_{female} = 0$$

$$H_A : \mu_{male} - \mu_{female} \neq 0$$

Data Collection Methods

In my study, the observational units were individuals residing on The Islands who consented to participate in my survey. The variables of interest, average hours of sleep last night (response variable, quantitative) and sex (explanatory variable, binary categorical), were measured through a survey that asked participants to report the number of hours they slept last night, along with their sex, age and other general questions. This survey was conducted at the two universities on The Islands, Hofn and Arcadia, and targeted a diverse population of students across different age groups and fields of study to ensure a representative sample. I aimed to survey an equal number of men participants and women participants. In total, I surveyed 33 women and 33 men. A total of 66 participants. The only thing that almost went wrong in collecting data was the fact that some participants were sleeping and I couldn't get their consent, which might have limited my pool of participants. Also, a couple of fields of studies had students entirely of the same sex, which also limited the diverse goal for my pool of participants. I decided to survey university students because I thought this might be the approach that limits the most confounding variables when it comes to sleep duration and patterns.

The variables measured were:

1. Biological Sex: This binary categorical variable represented the sex of the individual, categorized as either Male or Female. The choice of this variable was motivated by its potential role in influencing various attributes or behaviors, including sleep patterns. This variable is the explanatory variable.

2. Hours of Sleep: This quantitative variable represented the average number of hours a student sleeps per night. The hours of sleep were rounded to the nearest quarter of an hour, recognizing that sleep patterns and duration significantly impact health, performance, and general well-being. This variable is the response variable.

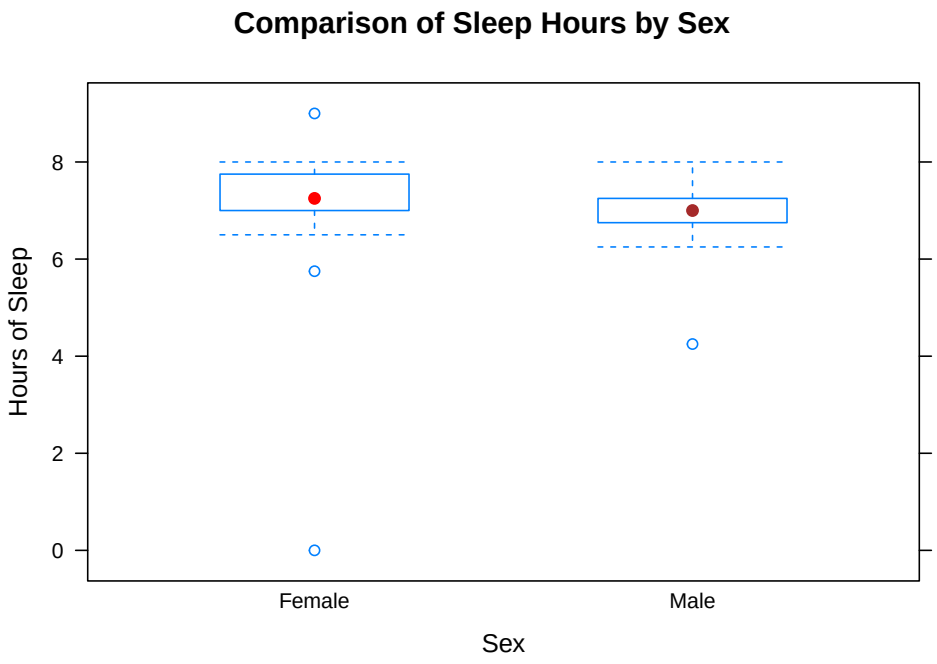
During the data collection process, I did not encounter significant issues. I mainly did not make repeat visits; if I found an Islander sleeping, I would move on to the next without repeating my visit. However, it's important to note that the data collection was confined to a specific group (university students) and might not represent the broader population of The Islands. Additionally, the self-reported nature of the sleep data might introduce a subjective bias, as students' perceptions of their sleep duration could differ from their actual sleep patterns. Despite these limitations, the study was carried out with a clear protocol, ensuring that the methodology could be replicated for further research in similar settings.

Descriptive Statistics

Here is a numerical visual summary of the data I collected

```
data <- read_csv('male_female_sleep.csv')
```

```
combined_data <- data.frame(
  Hours_of_Sleep = c(data$Male, data$Female),
  Gender = rep(c("Male", "Female"), each = nrow(data))
)
bwplot(Hours_of_Sleep ~ Gender,
       data = combined_data,
       main = "Comparison of Sleep Hours by Sex",
       xlab = "Sex",
       ylab = "Hours of Sleep", col = c("red", "brown"))
```



The provided boxplot illustrates the distribution of sleep hours by sex, with separate boxes for females and males. From observing the plot, I can discern several points about the data:

Central Tendency The red dot in each box, which indicates the median, is situated higher for females than males. This suggests that the central tendency of sleep hours is slightly greater for females than for males.

Spread of the Data The boxes represent the interquartile range (IQR) and appear to be of similar size for both sexes, indicating that the spread or variability of sleep hours around the median is roughly comparable between females and males.

Outliers The presence of outlier points (depicted as hollow circles) for both sexes suggests that there are individuals whose sleep hours fall significantly outside the typical range. This is particularly noticeable for females, where there are two outliers, one above and one below the box, suggesting that some females report much higher or lower sleep hours than the average. Furthermore, there is one extreme outlier (zero hours of sleep) that might affect the validity conditions of a two-sample t-test. I will discuss this in detail moving forward.

Overall Distribution The distribution for males seems to be slightly skewed towards the lower end, whereas the female distribution appears more symmetric.

Association Between Variables While the boxplot alone does not establish causation or a strong correlation, the higher median for females could indicate a tendency for females to sleep more than males, suggesting a possible association between sex and sleep hours.

Simulation-Based Approach Given the extreme outlier in the female data, the validity conditions of a two-sample t-test are violated. Therefore, it is necessary to conduct a simulation-based approach to compare, contrast and verify my findings.

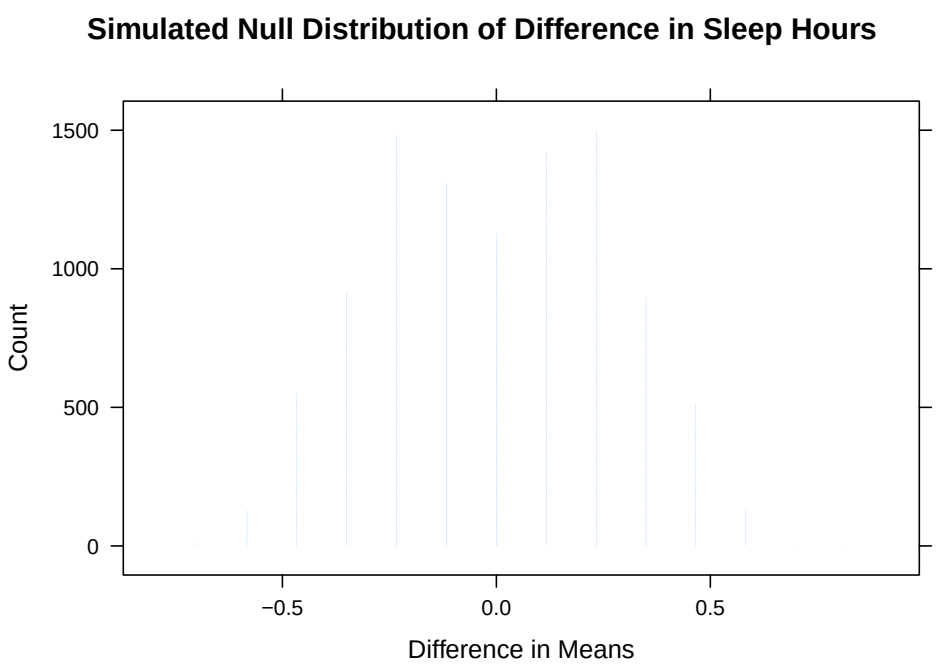
```
sleep_data <- read_csv("sleep_times_data.csv")
```

```
set.rseed(107)

obs_diff <- with(sleep_data, mean(time[sex == "Male"]) - mean(time[sex == "Female"]))
n_simulations <- 10000
null_distribution <- replicate(n_simulations, {
  shuffled_time <- sample(sleep_data$time)
  mean(shuffled_time[sleep_data$sex == "Male"]) - mean(shuffled_time[sleep_data$sex == "Female"])
})
```

```
sleep_null <- data.frame(DifferenceInMeans = null_distribution)

dotPlot(~DifferenceInMeans, data = sleep_null, main="Simulated Null Distribution of Difference in Sleep
```



This dot plot generated from the simulation-based approach visualizes the null distribution of the difference in mean sleep hours between sexes, showing a central tendency around zero with no significant skew. This pattern indicates that the simulation aligns with the t-test results that follow later in the report, which also found no significant difference in sleep hours between male and female students on The Islands. The congruence of these findings supports the conclusion that there is no evidence of a gender difference in sleep duration within the studied population.

Favorite Statistics The following is the fav_stats function conducted on both the female data and the male data. The results are shown below each code.

```
favstats(time ~ sex, data = sleep_data)
```

```
##      sex  min   Q1 median   Q3 max     mean        sd  n missing
## 1 Female 0.00 7.00   7.25 7.75   9 7.090909 1.3958899 33       0
## 2   Male 4.25 6.75   7.00 7.25   8 6.969697 0.6839613 33       0
```

```
favstats_male <- favstats(~Male, data = data)
favstats_male
```

```
##   min   Q1 median   Q3 max     mean        sd  n missing
##  4.25 6.75      7 7.25   8 6.969697 0.6839613 33     987
```

```
favstats_female <- favstats(~Female, data = data)
favstats_female
```

```
##  min Q1 median   Q3 max     mean      sd  n missing
##    0  7   7.25 7.75   9 7.090909 1.39589 33     987
```

Analysis of Results

Next up, I am conducting a test of significance and a confidence interval about the population parameter. The populations in question are all male and female unviersity students on The Islands. The parameters are the true average (mean) hours of sleep per night for these two populations. I am looking to conpare the

true average sleep durations to see if there is a significance difference between them. Let's start wit hthe hypotheses:

Null Hypothesis (H_0): There is no difference in the average hours of sleep per night between male and female university students on The Islands. Symbolically, this can be represented as $\mu_{male} = \mu_{female}$ where μ denotes the population mean.

Alternative Hypothesis (H_A): There is a difference in the average hours of sleep per night between male and female university students on The Islands. Symbolically, this can be represented as $\mu_{male} \neq \mu_{female}$.

I would also need to consider the types of errors that could arise in this study. Type I Error would occur if I wrongly conclude that there is a difference in the average hours of sleep per night between the two sexes when, in fact, no such difference exists. Type II Error would happen if we fail to detect a difference in the average hours of sleep per night between the two genders when there actually is one.

Representativeness Moreover, the representativeness of the sample plays a crucial role in the study. The representativeness of my measurements depends on the sampling method used. In my case, I picked three students from each field of study form both Hofn and Arcadia Universities using a random number generator for each field of study. I had to run my random number generator multiple times to ensure I get a random selection of students were I have an equal number of men and women. So, the process ensures that each student had an equal chance of being selected. Therefore, I can consider my sample to be reasonably representative of the university student population on The Islands. It is also worth considering that my findings may not generalize to all populations on The Islands, since my sample is confined to unversity students.

For a theory-based approach, we typically would use a two-sample t-test to compare the means of two independent groups when the population standard deviations are unknown and assumed to be unequal. Here's my approach to the analysis:

Standardized Statistic and Validity Conditions The appropriate standardized statistic is the t-statistic from a two-sample t-test. The validity conditions for this test are independence within groups (each individual's sleep hours are independent of each other's), independence between groups (the two groups are independent, which is reasonable given the randomly selected students from separate universities), normality (The sampling distribution of the difference in means should be approximately normal due to the Central Limit Theorem), and sample size is large enough ($n > 20$).

Below is a summary of the t-statistic results

```
t_test_results <- t.test(data$Male, data$Female, alternative = "two.sided", var.equal = TRUE)
c(t_test_results)
```

```
## $statistic
##          t
## -0.4479469
##
## $parameter
## df
## 64
##
## $p.value
## [1] 0.6557042
##
## $conf.int
## [1] -0.6617874  0.4193632
## attr(,"conf.level")
## [1] 0.95
##
## $estimate
## mean of x mean of y
```

```
##  6.969697  7.090909
##
## $null.value
## difference in means
##                   0
##
## $stderr
## [1] 0.2705948
##
## $alternative
## [1] "two.sided"
##
## $method
## [1] " Two Sample t-test"
##
## $data.name
## [1] "data$Male and data$Female"
```

The t-statistic value is -0.4479469, which represents the standardized difference between the means of the two groups (male and female sleep hours). A negative value indicates that the mean of the first group (males) is lower than the mean of the second group (females). However, the magnitude of this value is relatively small, suggesting that the difference in means is less than one standard deviation away from zero.

The p-value is 0.6557042 which is much greater than the significance levels of 0.05, indicating that there is no statistically significant evidence to reject the null hypothesis. In other words, the probability of observing a difference in average sleep hours as extreme as the one in our sample, or more extreme, given that there is no actual difference in the population, is quite high (about 65.57%).

Therefore, given the high p-value, I would not reject the null hypothesis. There isn't sufficient evidence to suggest a significant difference in the average hours of sleep per night between male and female university students on The Islands. This result aligns with the confidence interval that includes zero [-0.6617874, 0.4193632], further indicating that a true difference in average sleep hours between sexes may not exist or is not detectable with this sample data. The t-test suggests that any observed difference in sleep hours between male and female students could easily be due to random chance rather than an actual difference in the population. I conclude that there isn't statistically significant evidence to suggest a difference in the average hours of sleep per night between male and female university students on The Islands.

Conclusion

In this study, I set out to investigate whether there is a difference in the average hours of sleep per night between male and female university students on The Islands. My approach was grounded in both descriptive and inferential statistics, beginning with the collection of data from a sample of students and culminating in a two-sample t-test to assess the significance of any observed differences.

From the descriptive statistics, including a side-by-side boxplot, I observed that while there appeared to be a slight difference in sleep hours—with female students reporting marginally more sleep than their male counterparts—the variability within each group was substantial, and the range of sleep durations overlapped considerably between the groups.

When I moved to inferential statistics, the t-test yielded a t-statistic of -0.4479469 and a p-value of 0.6557042, indicating that the difference in mean sleep hours between sexes was not statistically significant. The confidence interval for the difference in means ranged from -0.6617874 to 0.4193632, which includes zero, further reinforcing the lack of statistical evidence to suggest a true difference in sleep patterns between male and female students.

The data did not show a clear difference as initially hypothesized, which was somewhat unexpected given prior research suggesting gender differences in sleep. However, it is important to note that my study's context—

university students on The Islands—may involve unique stressors and lifestyle factors that could influence sleep patterns, making direct comparisons to broader populations or other research findings challenging.

In terms of generalization, while my sample was randomly selected and balanced in terms of sexes, it was still a convenience sample from only two universities. This raises questions about the extent to which I can generalize my findings to all university students on The Islands, let alone to a non-student population.

If I were to conduct this study again, diversifying the sample to include more universities and possibly non-student populations could improve generalizability. This could be done by systematically sampling non-student populations of all ages. Additionally, employing objective measures of sleep could complement self-reported sleep data and address potential biases in reporting. Other factors that could influence sleep are academic stress, electronic usage before bed or caffeine consumption. Expanding the scope to consider these variables might provide a more nuanced understanding of sleep patterns among university students and contribute to the broader conversation about sleep health in young adults.

Bibliography: references to literature mentioned in the introduction

Mallampalli, M. P., & Carter, C. L. (2014). Exploring Sex and Gender Differences in Sleep Health: A Society for Women's Health Research Report. Journal of Women's Health (Larch- mont, N.Y. 2002), 23(7), 553–562. https://doi.org/10.1089/jwh.2014.4816