

CSE 163 Final Project: Spring 2023

Sleepless Nights: How Insomnia Affects Your Health and Well-Being

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Summary

Research Question #1: How does sleep duration impact age groups (40-59) and genders (M/F) in relation to the potential presence of insomnia?

The research findings reveal that sleep duration decreases as individuals age within the 40-59 age range. On average, females tend to have slightly higher sleep durations compared to males in the same age groups. These patterns suggest a potential relationship between age, sleep duration, and the presence of insomnia.

Research Question #2: How does sleep quality, sleep duration, and stress level relate to each other among individuals with insomnia in the age range of 40-59?

The scatter plot reveals a strong relationship between sleep quality, sleep duration, and stress level in people aged 40 to 59 who suffer from insomnia. With a very high correlation measurement, it appears that better sleep quality is related to longer sleep durations, whereas higher stress levels are related to poorer sleep quality. As a result of the profound connection between sleep and stress, people who suffer from insomnia need to value both their mental health and their amount of sleep for better health.

Research Question #3: How does heart rate and sleep quality correlate with the potential presence of insomnia?

The line chart shows a correlation with the potential presence of insomnia by depicting heart rate and sleep quality. Analysis from the dataset reveals that a heart rate of 60 corresponds to high sleep quality, while higher rates, nearing 100, indicate lower quality. Higher heart rates may signify disrupted sleep patterns and potential insomnia. Further research is needed to fully understand this relationship.

Motivation

The objective of this study is to investigate the effects of insomnia on an individual's health and well-being. Insomnia is a prevalent sleep disorder that is characterized by difficulty in initiating or maintaining sleep, leading to negative consequences such as daytime fatigue, impaired work performance, and reduced quality of life. Moreover, insomnia has been linked to the development of several chronic health conditions, including cardiovascular disease, obesity, and depression. This study aims to systematically review the literature to investigate the impact

of insomnia on various health outcomes, including physical health, mental health, and overall quality of life using various datasets. Finally, the study proposes to investigate the effects of insomnia on health and well-being, with the ultimate goal of understanding the close relationship of sleep and well-being.

Data Setting

- <https://www.kaggle.com/datasets/equilibriumm/sleep-efficiency>
- <https://www.kaggle.com/datasets/danagerous/sleep-data>
- <https://www.kaggle.com/datasets/uom190346a/sleep-health-and-lifestyle-dataset>

Methodology

1) Conduct a comprehensive search of relevant databases, like Kaggle, data.gov, google dataset search, CDC National Center of health Statistics Data, using relevant keywords such as "insomnia," "sleep disorders," "health outcomes," and "treatment." This will help us find the different datasets.

- This will assist us in discovering datasets containing the relevant variables so that we can perform trends and relationships to determine how sleep varies by various variables and how it affects our health.

2) Briefly look through the resulting studies for relevance, including studies that investigate the impact of insomnia on health outcomes, studies that compare the effectiveness of different insomnia treatments, and studies that examine the prevalence and incidence of insomnia.

- This will help us understand what we need to do with the dataset, such as cleaning and removing missing data, in order to achieve the best possible result with no errors

3) Extract/combine relevant data from the included studies, including the design of the study, sample size, treatment approaches, and outcomes. (Choose which variables and plot type will best describe the relationship.)

- Bar chart: Sleep duration + different age, gender -> **research question 1**: How does heart rate and sleep quality correlate with the potential presence of insomnia
- Scatter Plot: Stress Level + Sleep quality/Sleep duration -> **research question 2**: How does sleep quality, sleep duration, and stress level relate to each other among individuals with insomnia
- Line Chart: Sleep quality + Heart Rate -> **research question 3**: how sleep insomnia affects our health

4) Analyze the extracted/combined data to get some detailed conclusions about the impact of insomnia on health outcomes and the effectiveness of different treatment approaches.

5) Synthesize the results of the included studies to identify common themes and trends, as well as areas of inconsistency or disagreement.

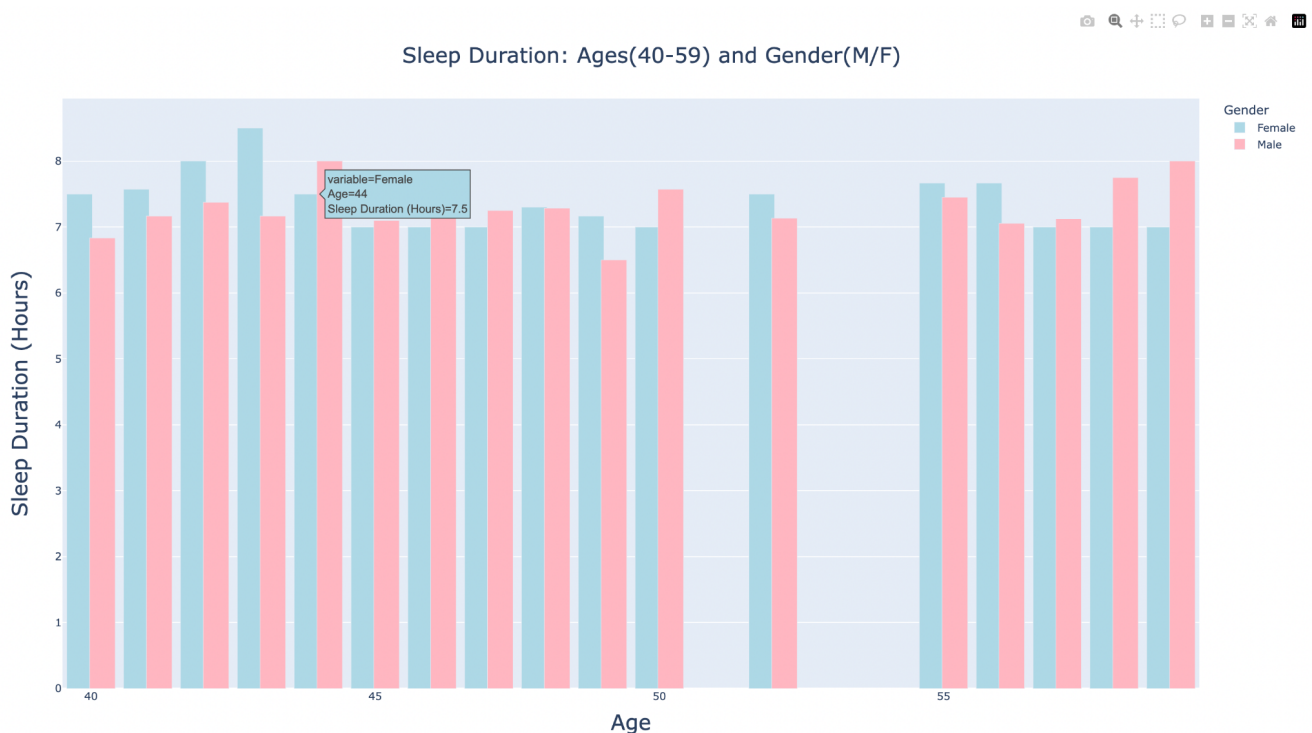
- From here, we can clearly see a connection between all of the factors affecting sleep efficiency.

6) Draw conclusions about the impact of insomnia on health outcomes, the effectiveness of different treatment approaches, and the overall state of the current evidence base.

- **challenge connected**: understand the harm of insomnia and figure out the factors that cause insomnia, we could draw a conclusion of how to get better sleep and increase health by avoiding negative factors and adjusting sleep length.

Results

Data Visualization #1:



RESEARCH QUESTION #1: How does sleep duration impact different age groups and genders in relation to the potential presence of insomnia?

This data visualization provides valuable insights into the impact of sleep duration on different age groups (40-59) and genders (M/F) regarding the potential presence of insomnia.

There is the X-axis representing the sleep duration in hours and the Y-axis representing the Age. There is also a key on the right that represents the male and female category. The bar for each of the two categories splits into two, blue and pink for each age, so that it is easier to compare. The visualization demonstrates that sleep duration tends to decrease as individuals get older within the 40-59 age range, with a few exceptions at ages 43 and 59. This was through calculating the means for all age groups 40-59. Additionally, on average, females tend to have slightly higher sleep durations compared to males within the same age groups.

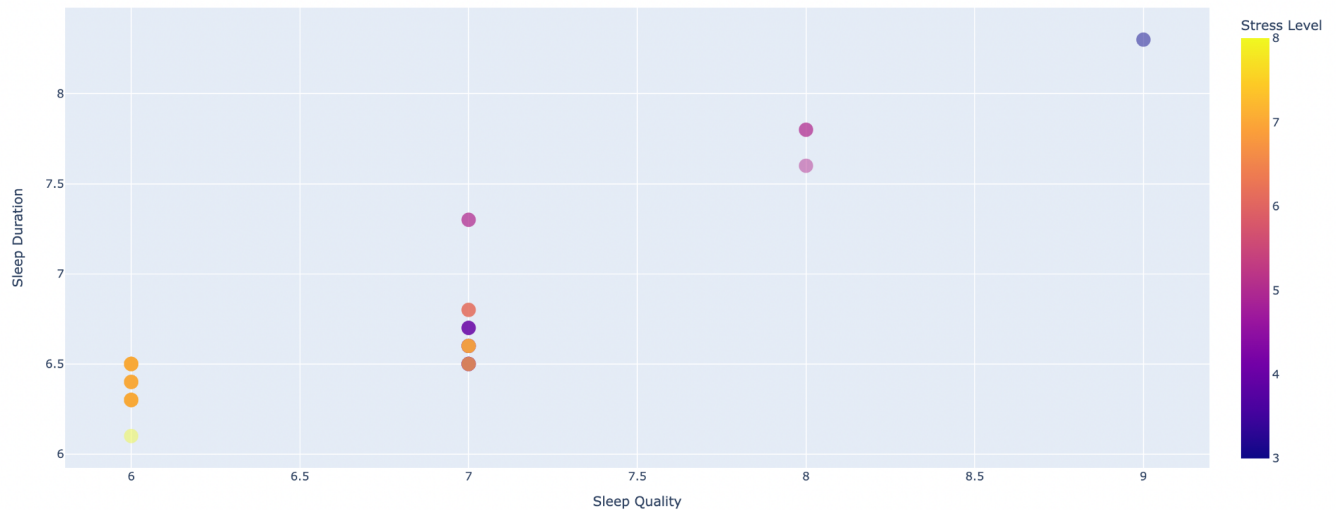
These findings from the data visualization align with the information gathered from the National Library of Medicine article, which highlights that many older adults experience dissatisfaction with the quantity and quality of sleep, even with adequate opportunity to sleep. The prevalence of insomnia is typically higher among older adults and increases with age. The article emphasizes that up to 50% of older adults report insomnia symptoms in the middle and older age groups. This suggests a strong connection between age, sleep disturbances, and the potential presence of insomnia.

Combining the insights from the data visualization and the article, it becomes evident that a decrease in sleep duration may serve as an indicative factor of insomnia. The visualization provides a visual representation of how sleep duration varies across age groups and genders, combining with the high prevalence of insomnia among older adults. These combined insights emphasize the importance of recognizing the potential consequences of insufficient sleep and addressing insomnia as a contributing factor to sleep disturbances, particularly among older adults. By acknowledging these relationships and implementing appropriate interventions, it is better to improve overall sleep quality and mitigate the negative impact of insomnia. Further research and understanding of the complex interplay between sleep duration, insomnia, and age will be valuable in developing effective strategies for the prevention and management of insomnia in diverse populations.

RESEARCH QUESTION #2: How does sleep quality, sleep duration, and stress level relate to each other among individuals with insomnia in the age range of 40-59?

Data visualization #2:

Quality & Length sleep with stress level of insomnia people age 40-59



Correlation between Quality of Sleep and Sleep Duration: 0.8045350043607005

Correlation matrix:

	Quality of Sleep	Sleep Duration	Stress Level
Quality of Sleep	1.000000	0.804535	-0.729543
Sleep Duration	0.804535	1.000000	-0.425810
Stress Level	-0.729543	-0.425810	1.000000

correlation for dependent level of Stress Level

R-Squared: 0.6058418686602386

Adjusted R-Squared: 0.5937139261574766

In order to figure out how sleep quality, sleep duration, and stress level relate to each other among individuals with insomnia in the age range of 40-59, we use a scatter plot to visualize the relationship between x-axis "Quality of Sleep", y-axis "Sleep Duration", and "Stress Level". We map the color of "Stress Level" for each value to investigate how it relates to the other two variables. We can also see the numeric connection, better conclusion from the plot, by measuring correlation coefficients between each variable.

Sleep Quality and Sleep Duration:

The dots at the intersection of these variables show the correlation between "sleep quality" and "sleep duration". There is a positive linear relationship between "Quality of Sleep" and "Sleep Duration" in the plot. Sleep duration increases as sleep quality improves. This relationship has a relatively high correlation coefficient of about 0.8, which means people who sleep for longer periods of time have better sleep quality.

Stress Level and Sleep:

From the plot, we can see that the stress level color darkens when it goes upward to the right, indicating that the stress level is decreasing as the sleep quality improves. This demonstrates the negative correlation between stress and sleep quality, as evidenced by the relatively high correlation coefficient of -0.73. The negative sign indicates a negative correlation between these two variables, implying that as "stress level" rises, "sleep quality" falls. This suggests that higher stress levels are linked to poorer sleep quality. The relationship between stress level and sleep duration is the same, with a correlation coefficient of -0.43.

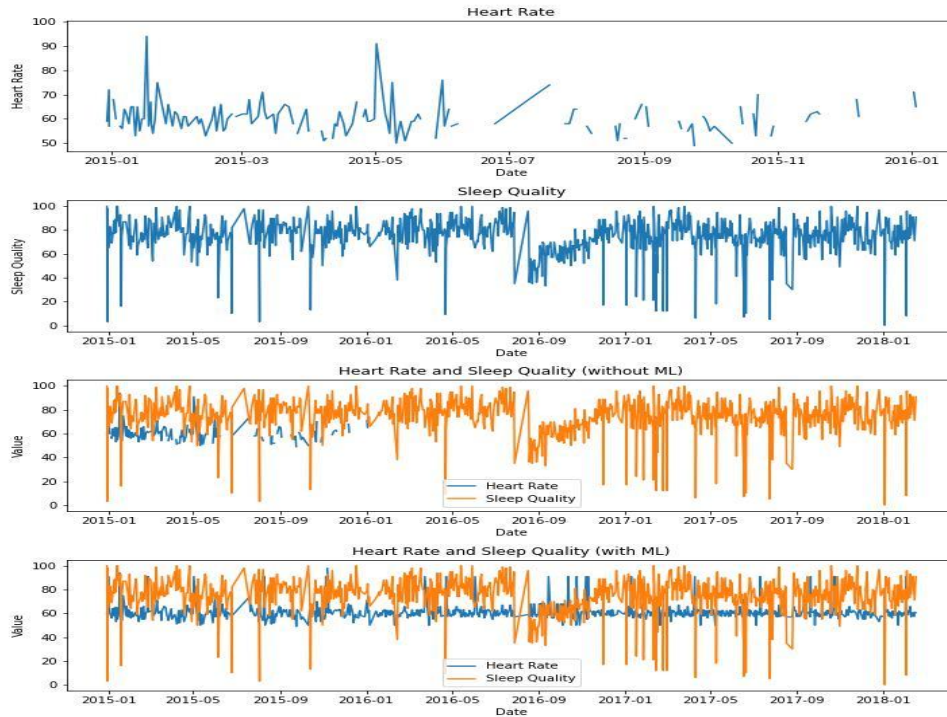
We calculated that the stress level is approximately 60% dependent on sleep, which is a moderately high level of dependence. This percentage demonstrates that stress and sleep are inseparably linked.

The article "How Stress Affects People's Health" from Baylor College of Medicine explains this relationship. Wilson explained "High levels of stress impair sleep by prolonging how long it takes to fall asleep and fragmenting sleep. Sleep loss triggers our body's stress response system, leading to an elevation in stress hormones, namely cortisol, which further disrupts sleep,". Our sleep duration and quality would suffer as a result of a stressful mind and people who do not get enough sleep may experience increased stress and exhaustion.

Overall, this data visualization provides useful insights into how "sleep quality," "sleep duration," and "stress level" are related to one another in people aged 40 to 59 who suffer from insomnia. It appears that better sleep quality is related to longer sleep durations, whereas higher stress levels are related to poorer sleep quality. As a result, sleep and stress are intrinsically connected. To improve our health, we should avoid stress in order to sleep better and set a sufficient bedtime to reduce stress, improve our sleep, and get better health.

RESEARCH QUESTION #3: How does heart rate and sleep quality correlate with the potential presence of insomnia?

Data Visualization #3:



The data visualization above depicts a strong correlation between an individual's heart rate and their sleep quality. The dataset used for this visualization was obtained from Sleep Cycle (SC), a mobile phone application that monitors various aspects of one's sleep cycle, including heart rate, time, date, and more. It is important to note that this visualization was created using a machine learning method. As we can observe from the visualization, it becomes evident that a heart rate of 60 corresponds to the highest sleep quality. However, during the time interval between September 2016 and January 2017, the sleep quality noticeably declined as the heart rate approached 100.

According to a study from Harvard Medical School, it is stated that heart rate naturally fluctuates during sleep. It generally decreases during the early stages of sleep and reaches its lowest point during deep sleep. Interestingly, these findings align with the data visualization presented earlier, where it was observed that heart rate reaches its lowest point during deep sleep, indicating a higher quality of sleep. This correlation between the study and the data visualization strengthens the understanding of how heart rate relates to sleep quality.

As mentioned above, during the initial phases of sleep, individuals often encounter more awakenings, and a higher heart rate during this period may indicate disrupted sleep patterns and challenges in achieving restful sleep. Insomnia, a prevalent sleep disorder, is characterized by difficulties in falling asleep, staying asleep, or experiencing both. Insomnia's presence can result in an elevated heart rate during sleep, which contributes to diminished sleep quality and increased daytime fatigue. Although further research is needed to fully understand the correlation between heart rate, sleep quality, and their impact on insomnia, the discovery of an initial correlation represents a significant step towards their complex relationship.

Finally, we did not use Plotly for this ML data visualization as it has 4 subplots and we thought it would be easier to compare without using Plotly.

Impact and Limitations

The results of the analysis on sleep duration, sleep quality, stress levels, and heart rate have important implications for various stakeholders. The potential implications of the results highlight the importance of recognizing and addressing insomnia as a significant factor impacting sleep duration, sleep quality, stress levels, and heart rate. Understanding the relationship between these variables can contribute to the development of targeted interventions and treatments for individuals suffering from insomnia.

Healthcare professionals can benefit from these findings by developing targeted interventions and treatment plans for individuals experiencing sleep problems or insomnia within the 40-59 age range. The strong correlations observed between sleep quality, sleep duration, and stress levels highlight the need for integrated approaches that address both mental well-being and sleep habits. However, it is essential to consider the limitations and biases of the analysis. The dataset used may not represent a diverse population, and the findings may not be generalizable to other age groups or individuals with different health conditions impacting their sleep. Furthermore, self-reporting biases and the use of prediction models for heart rate introduce potential limitations. Therefore, while the analysis provides valuable insights, it should be used as a foundation for further research and personalized advice from healthcare professionals.

Challenge Goals

Challenge Goal #1: External Library (PLOTLY)

Our project goal for this is to utilize the Plotly library to visualize sleep data more efficiently and effectively. We personally chose Plotly because of its rich and interactive data visualization capabilities. We believe that by leveraging Plotly into this project, we can create visually appealing and interactive charts that enhance the understanding of sleep patterns and contribute to a more engaging data exploration experience. However, for our final data visualization we did not leverage Plotly into our graph because we had four subplots and it would be easier for the audience to compare all on the same page.

Challenge Goal #2: Machine Learning

Another challenge of our project is to apply machine learning methods to gain insights about the sleep data beyond what is traditionally taught in a class setting. We chose to utilize the Decision Tree Regressor algorithm to predict missing heart rate values based on sleep quality. To assess whether this goal is met, we will evaluate the performance of the Decision Tree Regressor model in predicting heart rate values accurately.

Furthermore, we can analyze the feature importance of the model, which will provide insights into which sleep-related factors, such as sleep quality, duration, or stress levels, contribute significantly to determining heart rate.

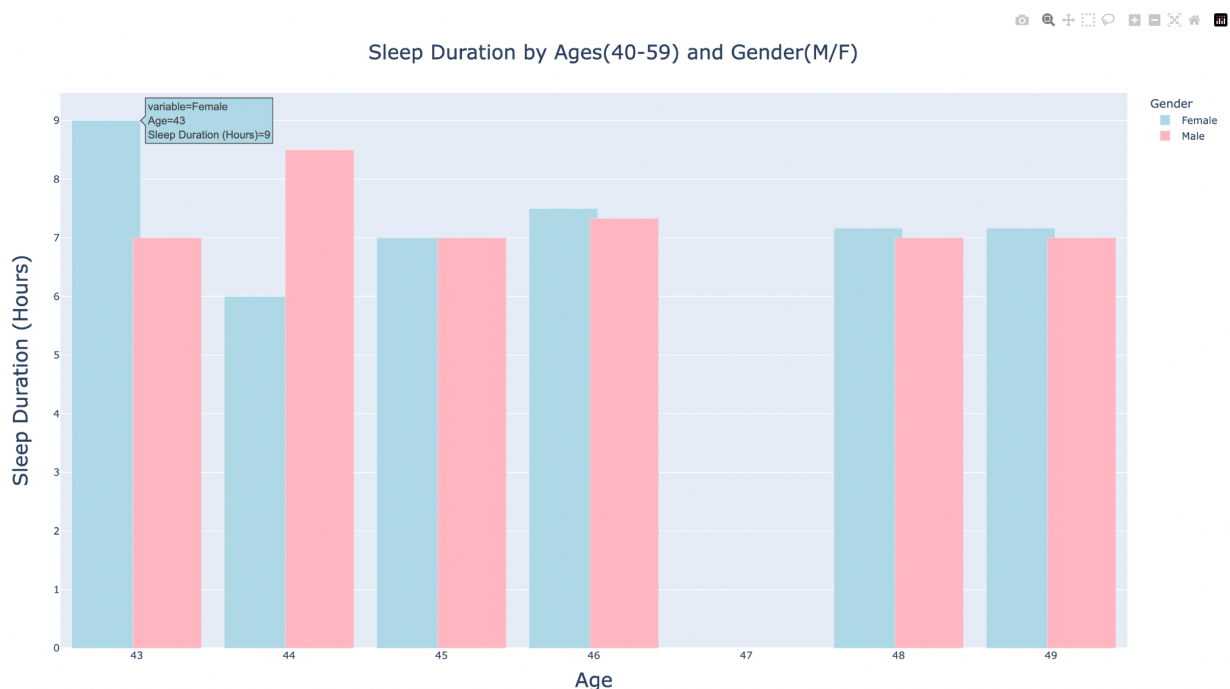
Plan Evaluation

Our proposed work plan turned out to be pretty accurate. Each team member in our group took on their fair share of tasks and actively supported one another throughout the project. Our estimates were close to reality because we greatly contributed to our successful project. There were some key factors that led to getting this type of great accuracy: effective communication & collaboration, zoom check-ins/calls, and dividing up the workload equally. Whenever we encountered challenges or needed assistance, we fostered a supportive environment within our team, where we readily offered help to one another. Moreover, we actively sought feedback from the teaching staff which helped us in delivering a high quality project.

Testing

We tested our code through smaller data files for all the data visualizations. We picked a small amount of data off our original datasets and compared our patterns/trends.

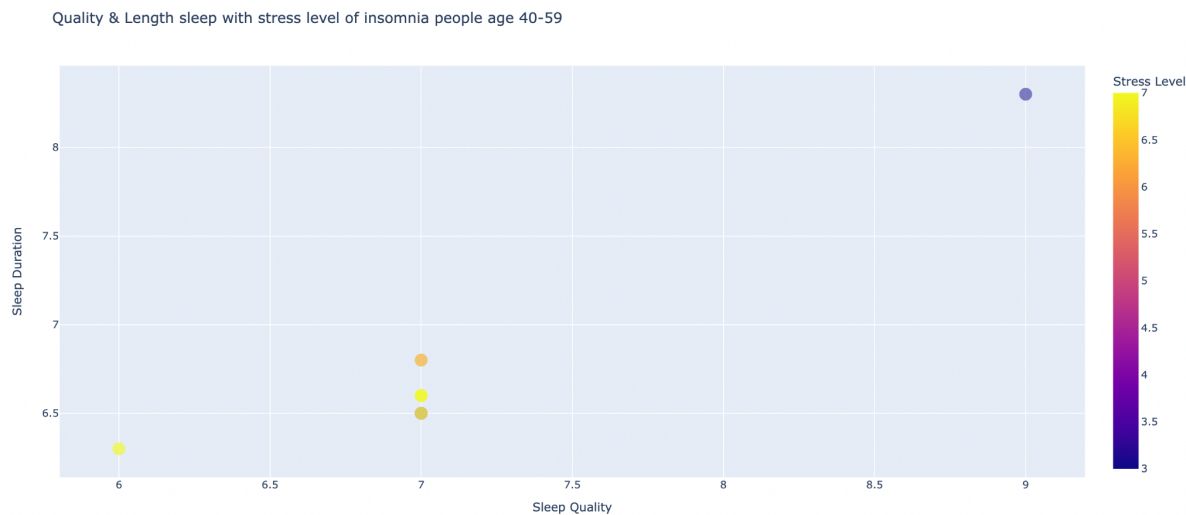
#1 BAR GRAPH TEST:



After testing with our smaller datasets, it was observed that the trend of females having slightly higher sleep durations than males within the age groups of 40-59 remained almost consistent (same trend as the original graph). There are very few instances of males had a higher sleep but that is as the limited sample/population size varied. So, the overall trend suggests that

females tend to have slightly more sleep than males in this age range, it is important to conduct further analysis with a larger dataset to validate these findings.

#2 SCATTERPLOT TEST:



Correlation between Quality of Sleep and Sleep Duration: 0.927938421194386

Correlation matrix:

	Quality of Sleep	Sleep Duration	Stress Level
Quality of Sleep	1.000000	0.927938	-0.644337
Sleep Duration	0.927938	1.000000	-0.613140
Stress Level	-0.644337	-0.613140	1.000000

correlation for dependent level of Stress Level

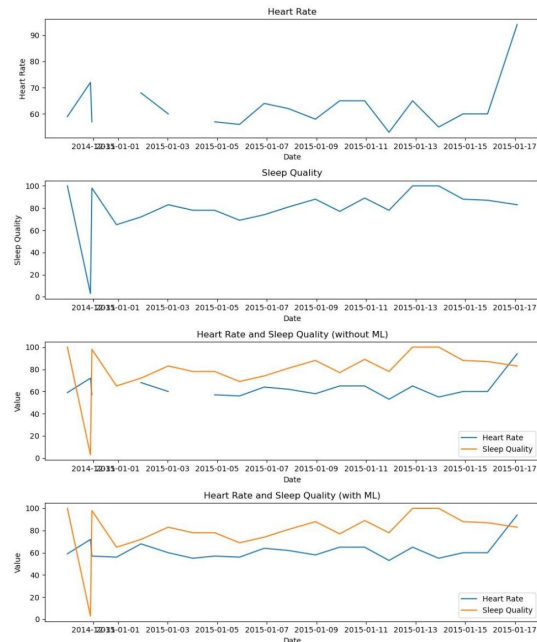
R-Squared: 0.4168403360145012

Adjusted R-Squared: 0.3002084032174015

After testing on a smaller dataset, the scatterplot shows the same trend, highlighting the tight connection between those variables. It still clearly demonstrates the strong positive correlation of sleep quality and sleep duration with a decent correlation coefficient about 0.9 and the negative correlation about -0.64 between stress and sleep quality.

The dependence percentage of stress level on the testing dataset is only about 30-40% which is weaker than the full dataset (60%); however, as the testing dataset is so much smaller, the dependence value could vary and weigh less.

#3 LINE CHART TEST:



After conducting tests with smaller datasets, we were able to observe consistent findings in the correlation between heart rate and sleep quality, both with and without the implementation of machine learning techniques. The trend observed in these smaller datasets aligned with our original visualization. Specifically, as heart rate fluctuated around 60, we consistently observed the highest sleep quality, suggesting the occurrence of deep sleep. These results further support the notion that heart rate and sleep quality are interconnected and indicate the potential significance of heart rate fluctuations in determining sleep depth.

Collaboration

We collaborated on this project, leveraging online resources to aid our progress and enhance our productivity.

Works Cited

- Brewster, Glenna S, et al. "Insomnia in the Older Adult." *Sleep Medicine Clinics*, Mar. 2018, www.ncbi.nlm.nih.gov/pmc/articles/PMC5847293/#:~:text=Many%20older%20adults%20experience%20difficulties,increase%20the%20risk%20for%20insomnia.
- Corliss, Julie. "How Does Sleep Affect Your Heart Rate?" *Harvard Health*, 29 Jan. 2021, www.health.harvard.edu/blog/how-does-sleep-affect-your-heart-rate-2021012921846.

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