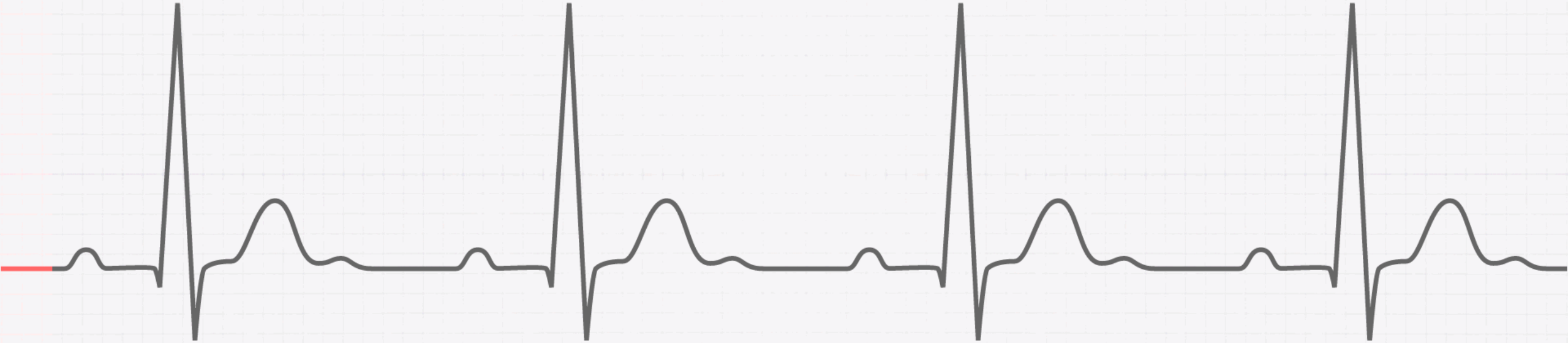
ANALYSIS OF DROWSINESS PATTERNS IN WEARABLE DEVIDE DATA

DATA DRIVEN INSIGHTS INTO DRIVER FATIGUE



BY MADO PROVATA

BACKGROUND

The inability to control the body in a drowsy state can be very dangerous (medhealth.Tech, 2024).

Behavioural signals are not enough to confirm resistance to drowsiness. Instead, heart rate and ppg signals may provide valuable information in understanding the activation and relaxation of the autonomous nervous system. (Hong et al., 2018).

AGENDA

01

OBJECTIVES

Goals and questions this analysis aims to answer

02

DATA OVERVIEW

Summarization of key characteristics of the data

03

VISUALIZATIONS

Visual description of data

04

INSIGHTS

Key findings and observations from analysis

05

RECOMMENDATIONS

Proposition of specific actions or strategies based on insights

OBJECTIVES

01

This analysis aims to understand the relationships between physiological signals of heart rate and PPG signals and drowsiness levels in individuals wearing smartwatches with vital signs sensors in different periods thorughout the day.

This analysis will help better understand the physiological markers of drowsiness and develop more robust and reliable algorithms for detecting and alerting users to potential sleepiness.

DATA OVERVIEW

Dataset: drowsiness_dataset.csv

02

Time periods

- **Morning**
- **Afternoon**
- **Evening**
- **Night**

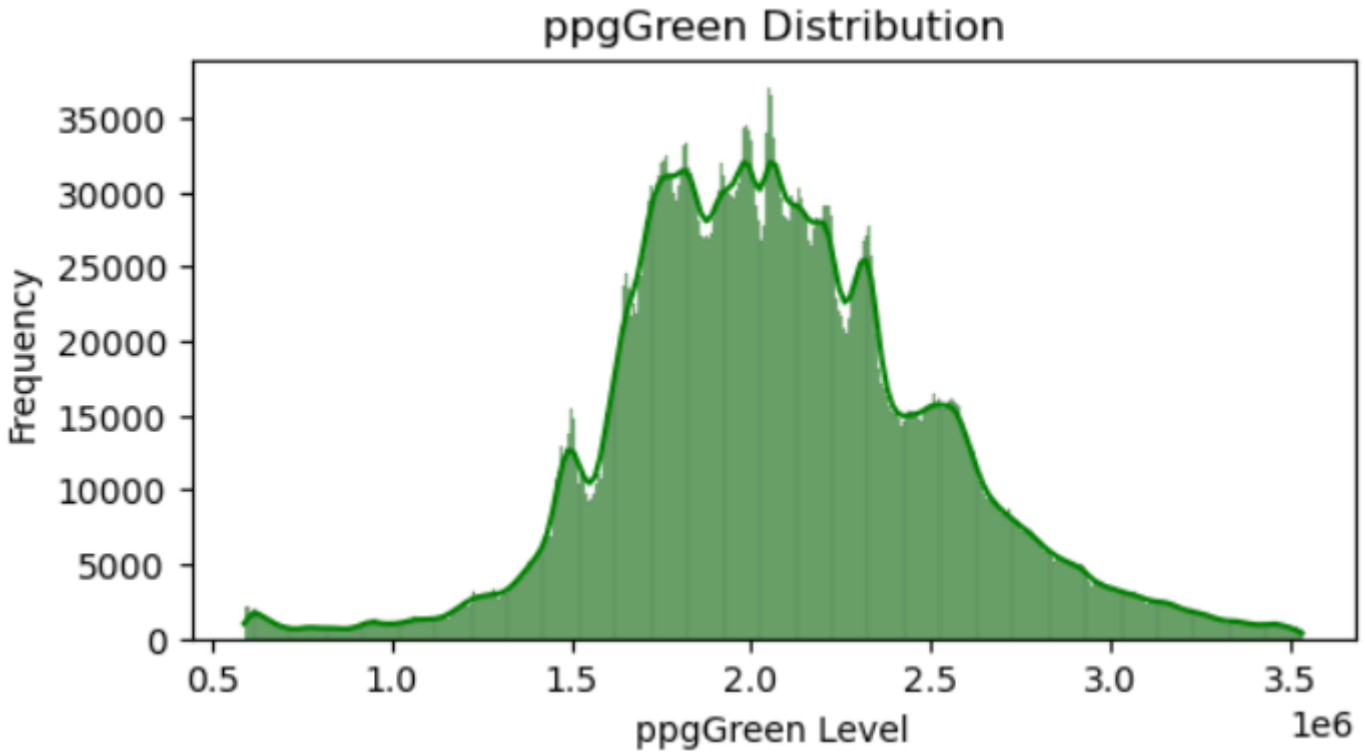
Columns:

- **Heart rate**
- **PPG Green (ppgGreen)**
- **PPG Red (ppgRed)**
- **PPG IR (ppgIR)**
- **Drowsiness**
  - **based on KSS**

Entries: 4890260
For the purpose of this analysis drowsiness levels are indicated as:

- **0.0 → low level of drowsiness**
- **1.0 → medium level of drowsiness**
- **2.0 → high level of drowsiness**

DISTRIBUTION OF PPG GREEN



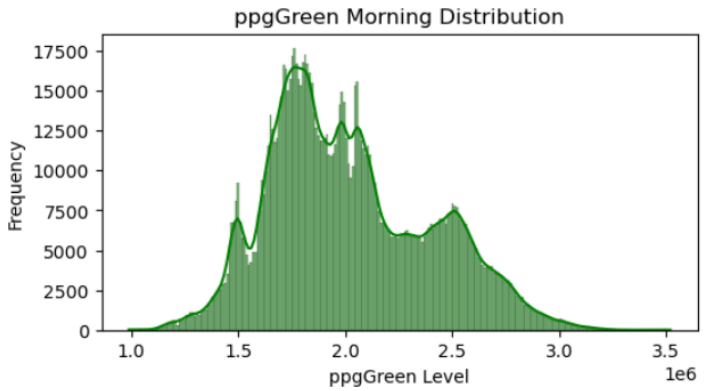
03

Key Insight:

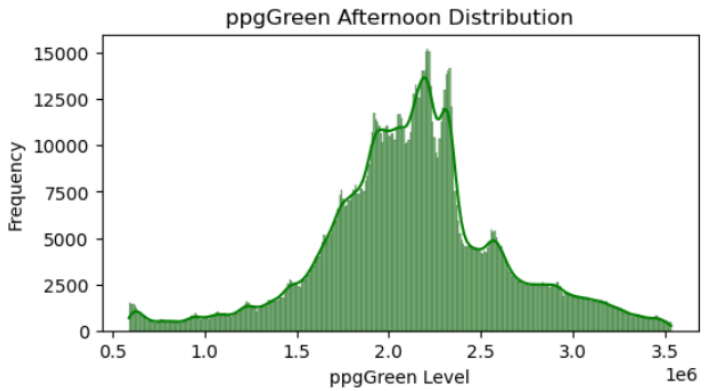
- The distribution of PPG Green shows most occurrences around the mean value of 2.0 x10^6, with some outliers.

DISTRIBUTION OF PPG GREEN ACROSS PERIODS

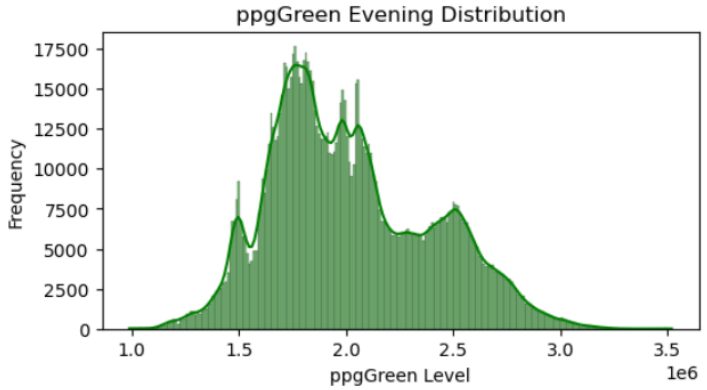
MORNING



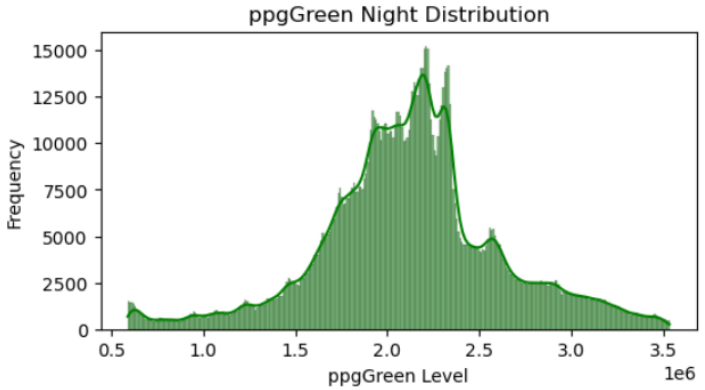
AFTERNOON



EVENING



NIGHT

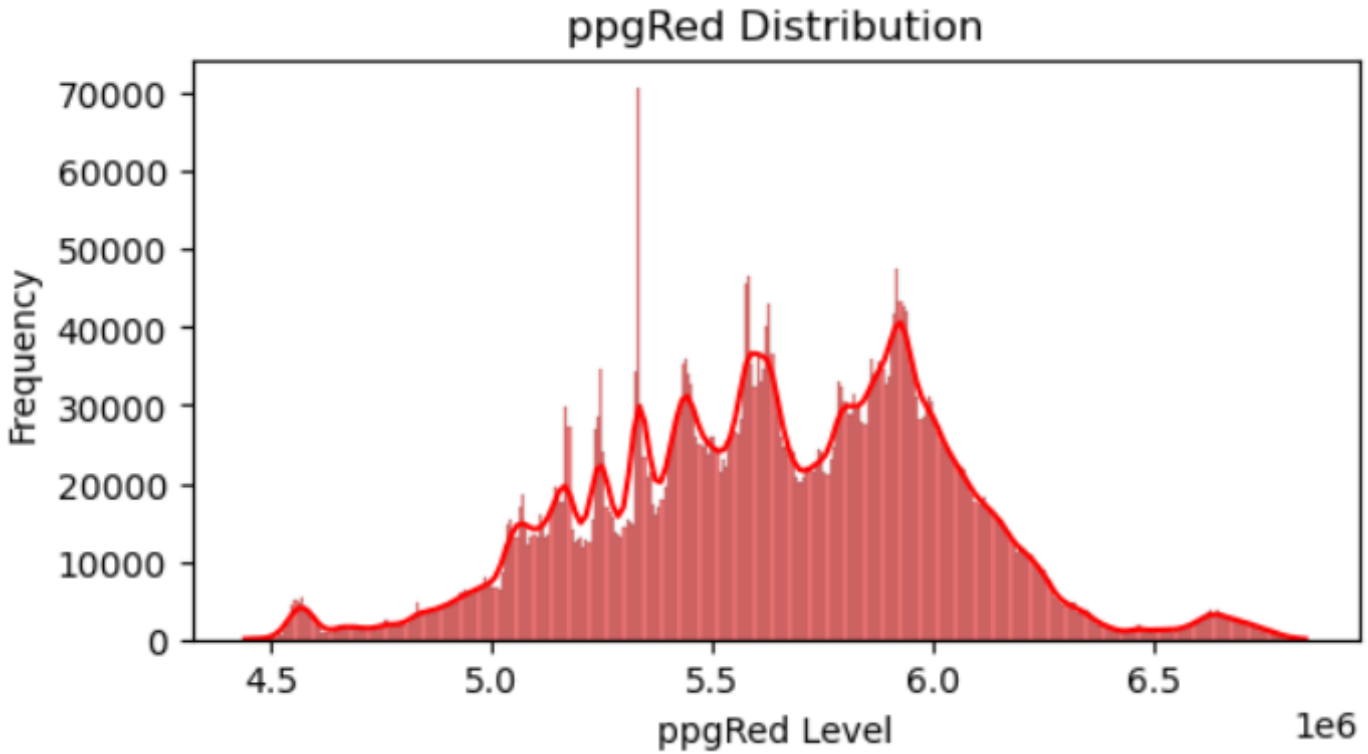


03

Key Insights:

- Graphs show some outliers in the data.
- Similar data patterns in the morning and evening periods.
- Similar data patterns in the afternoon and night periods.

DISTRIBUTION OF PPG RED



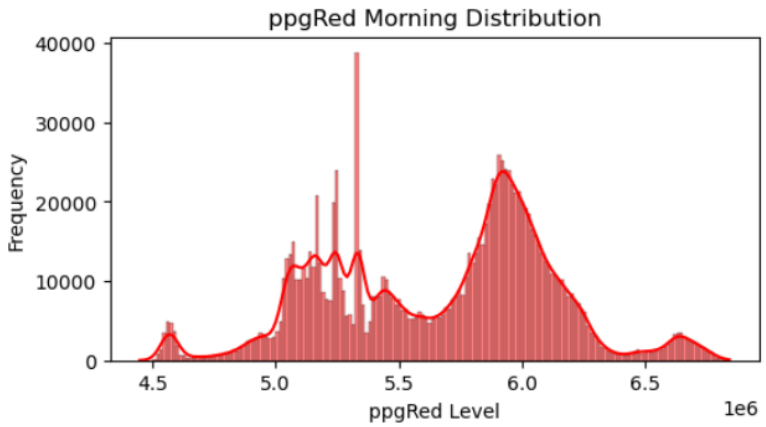
03

Key Insight:

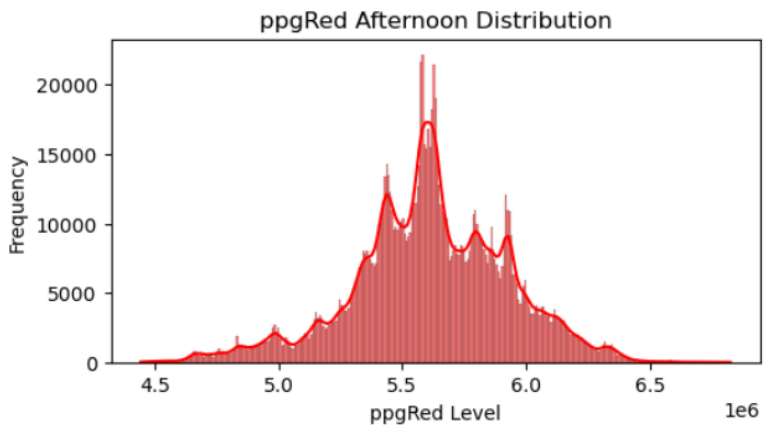
- The distribution of PPG Red shows most occurrences slightly above the mean value of 5.6 x 10^6, with notable outliers.

DISTRIBUTION OF PPG RED ACROSS PERIODS

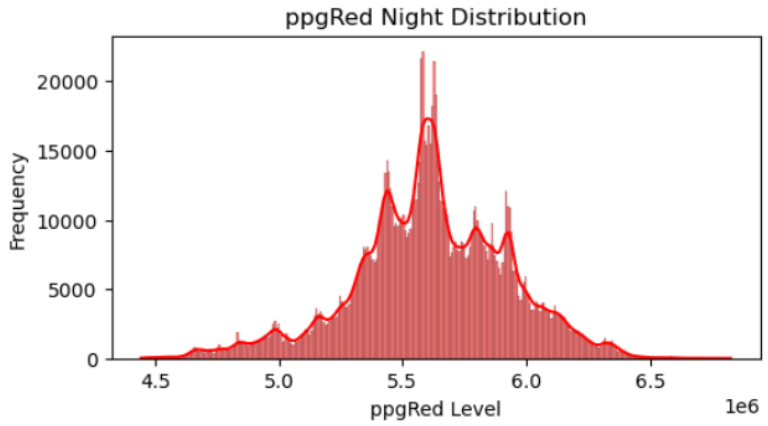
MORNING



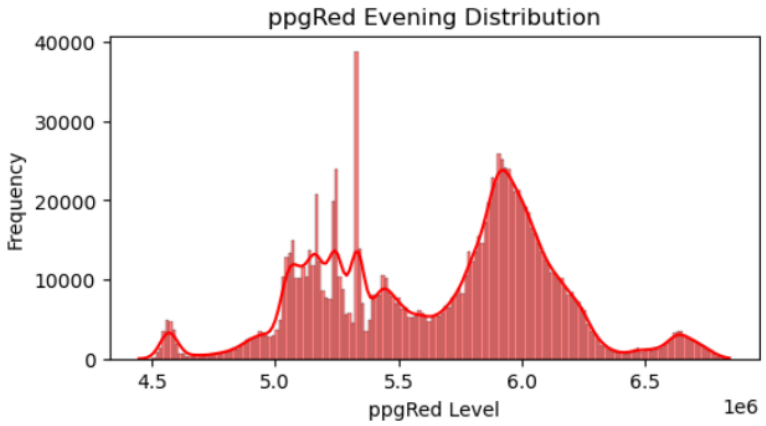
AFTERNOON



EVENING



NIGHT

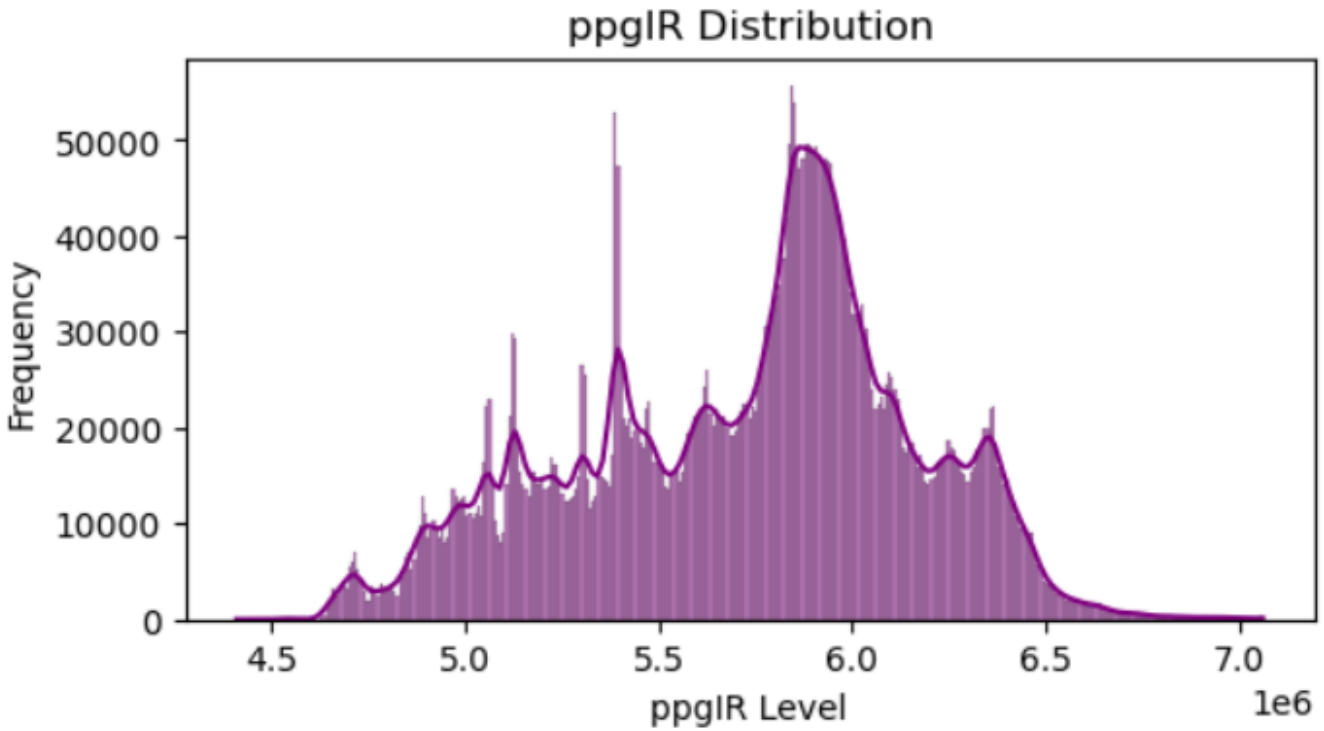


03

Key Insights:

- Significantly more outliers in the morning and night periods.
- Similar data patterns in the morning and night periods.
- Similar data patterns in the afternoon and evening periods.

DISTRIBUTION OF PPG IR



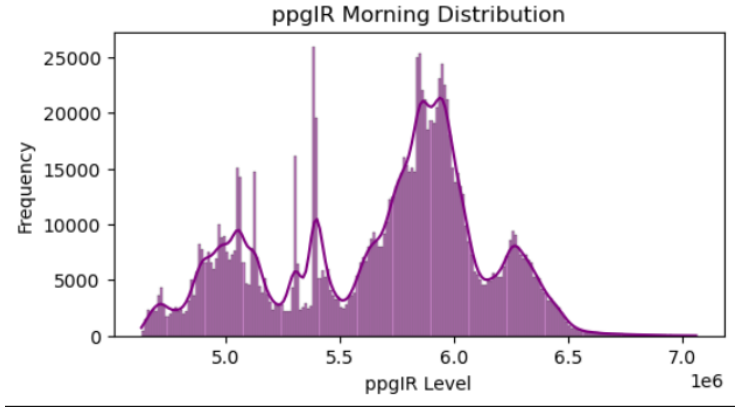
03

Key Insight:

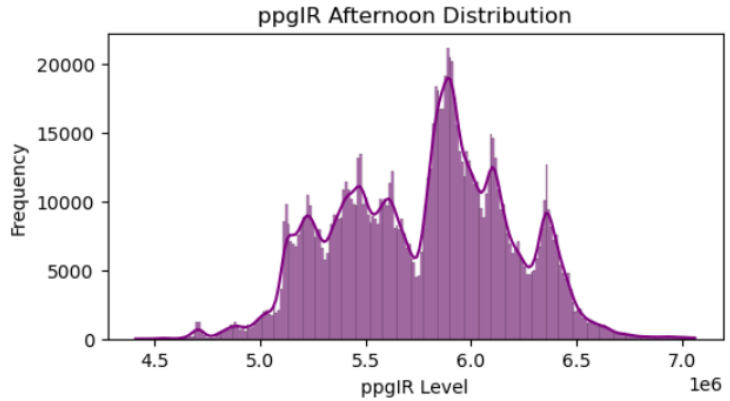
- The distribution of PPG IR shows most occurrences slightly higher than the mean value of 5.7 x 10^6, with notable outliers.

DISTRIBUTION OF PPG IR ACROSS PERIODS

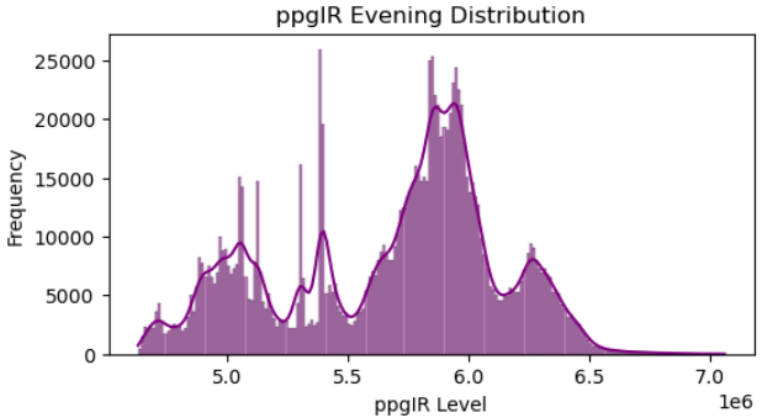
MORNING



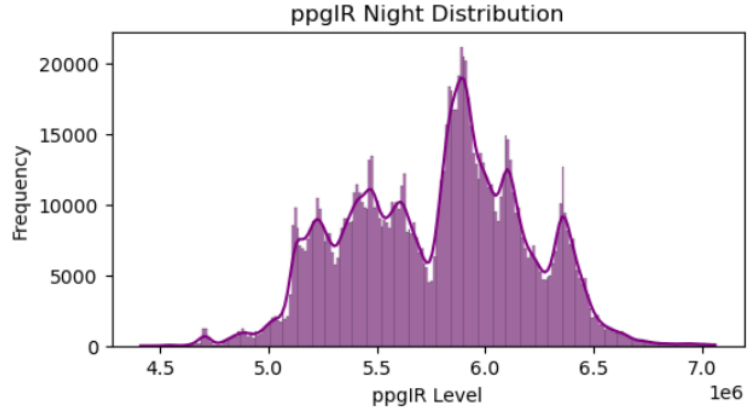
AFTERNOON



EVENING



NIGHT

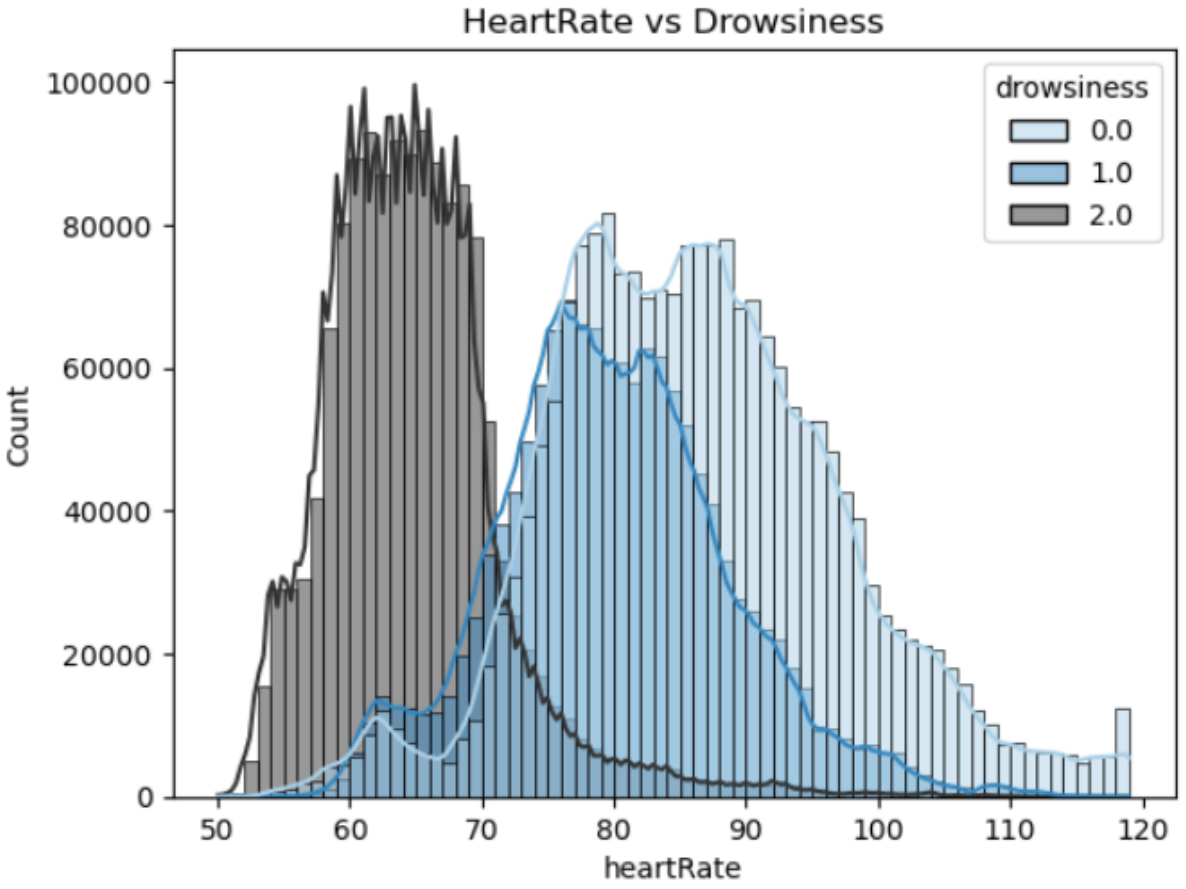


03

Key Insights:

- Significantly more outliers in the morning and evening periods.
- Similar data patterns in the morning and evening periods.
- Similar data patterns in the afternoon and night periods.

DISTRIBUTION OF HEART RATE BY DROWSINESS LEVEL



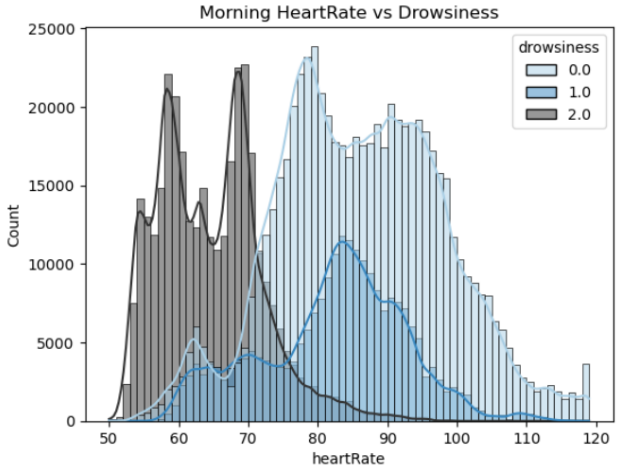
03

Key Insights:

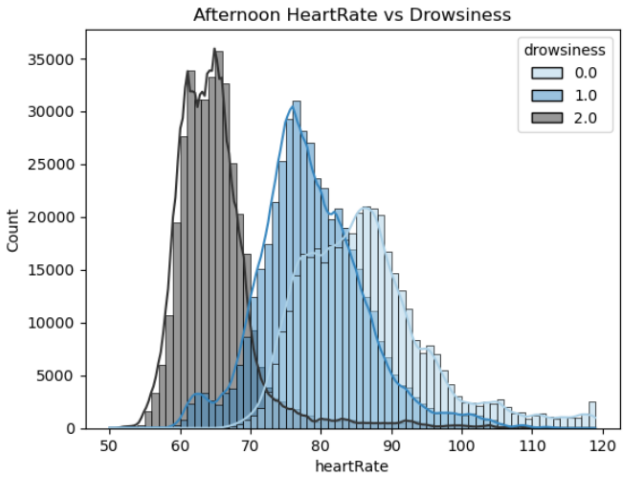
- Higher drowsiness levels at minimum heart rate values (within 50-60 bpm).
- No drowsiness levels at highest heart first values (115-120 bpm).

DISTRIBUTION OF HEART RATE BY DROWSINESS LEVEL ACROSS PERIODS

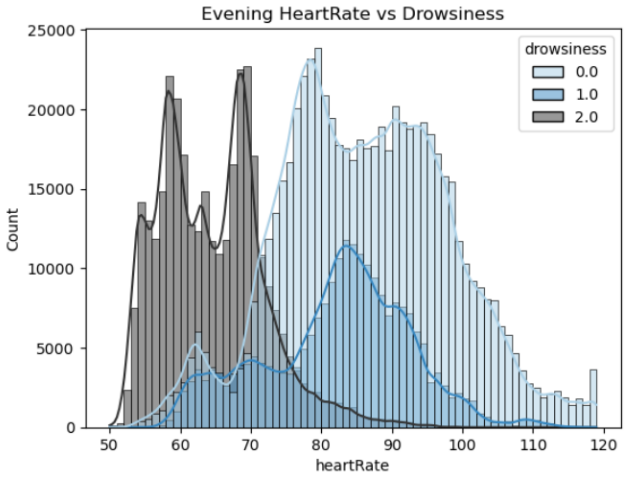
MORNING



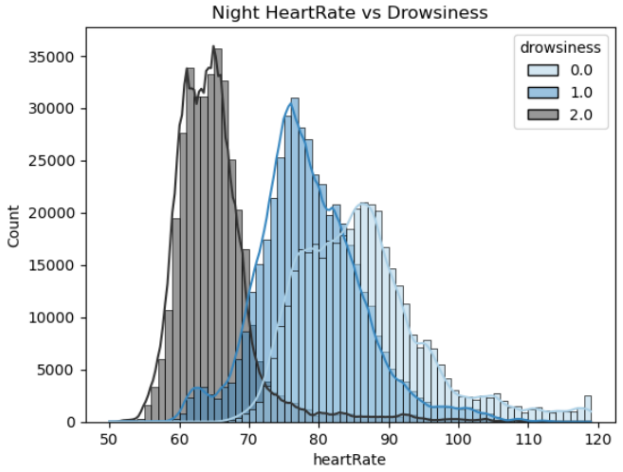
AFTERNOON



EVENING



NIGHT

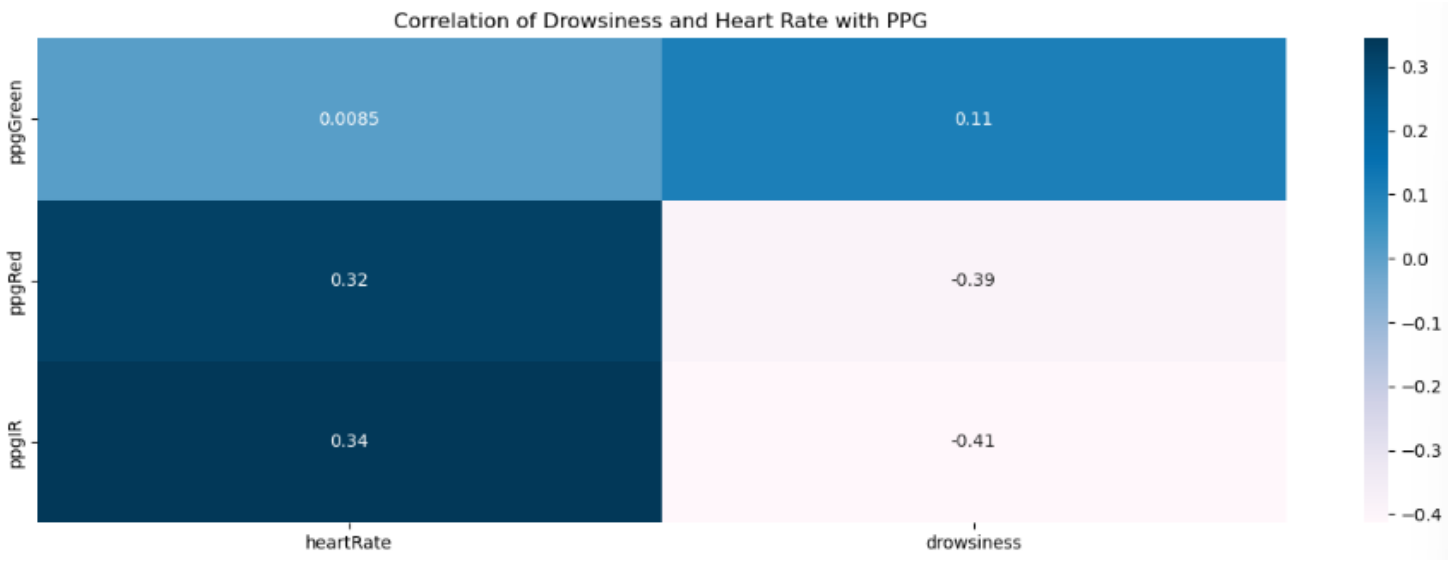


03

Key Insights:

- More instance of no drowsiness in the morning and evening times when heart rate is above 70 bpm.
- More instances of increased drowsiness in the morning and evening times when heart rate is less than 70 bpm

CORRELATION OF DROWSINESS AND HEART RATE WITH PPG



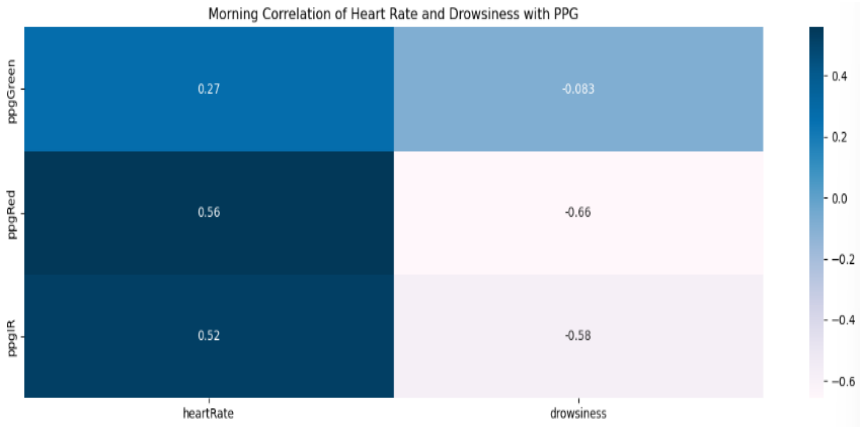
03

Key Insights:

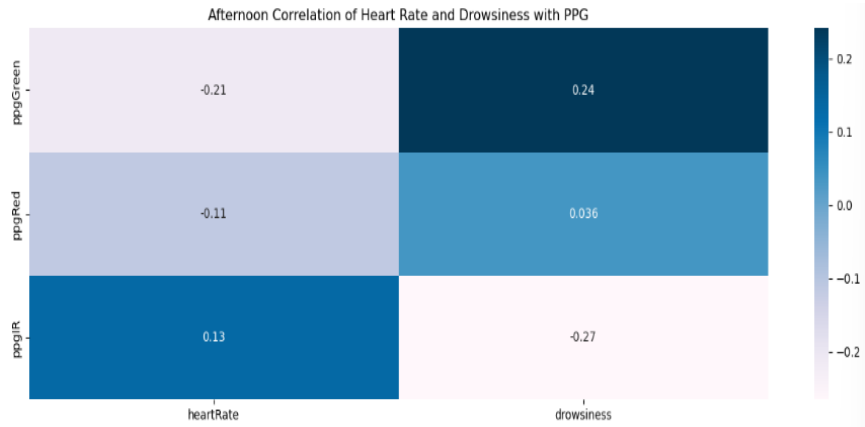
- Stronger correlation between heart rate and PPG IR (0.34), but weaker correlation between PPG IR and drowsiness (-0.41)
- PPG green shows stronger correlation with drowsiness levels (0.11)

CORRELATION OF DROWSINESS AND HEART RATE WITH PPG LEVEL ACROSS PERIODS

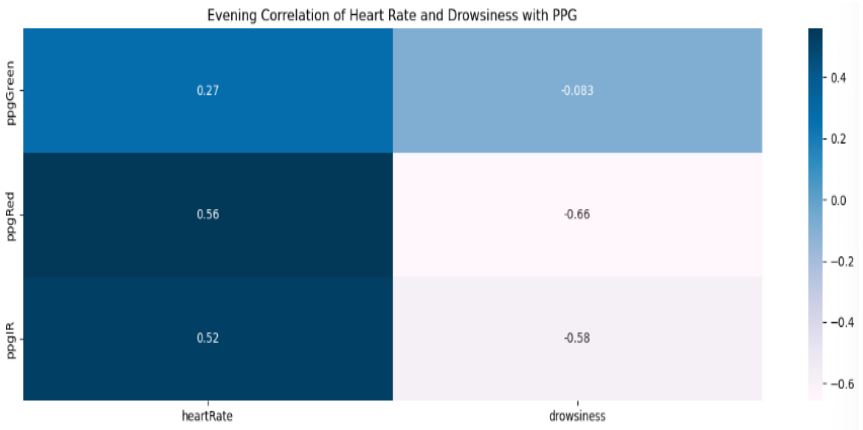
MORNING



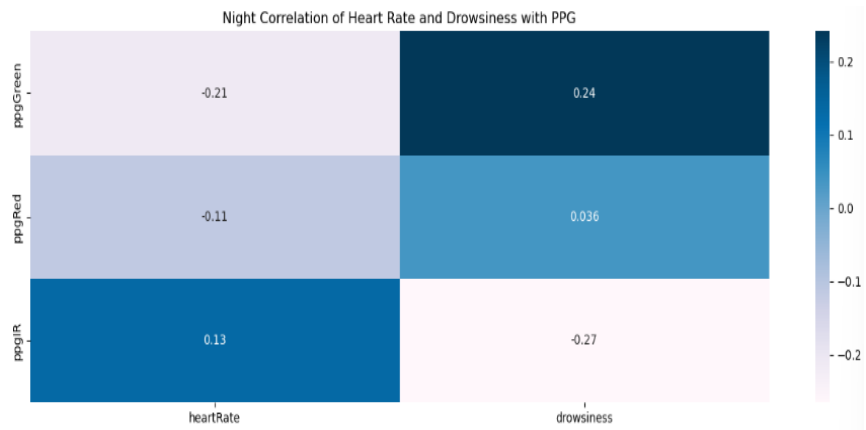
AFTERNOON



EVENING



NIGHT

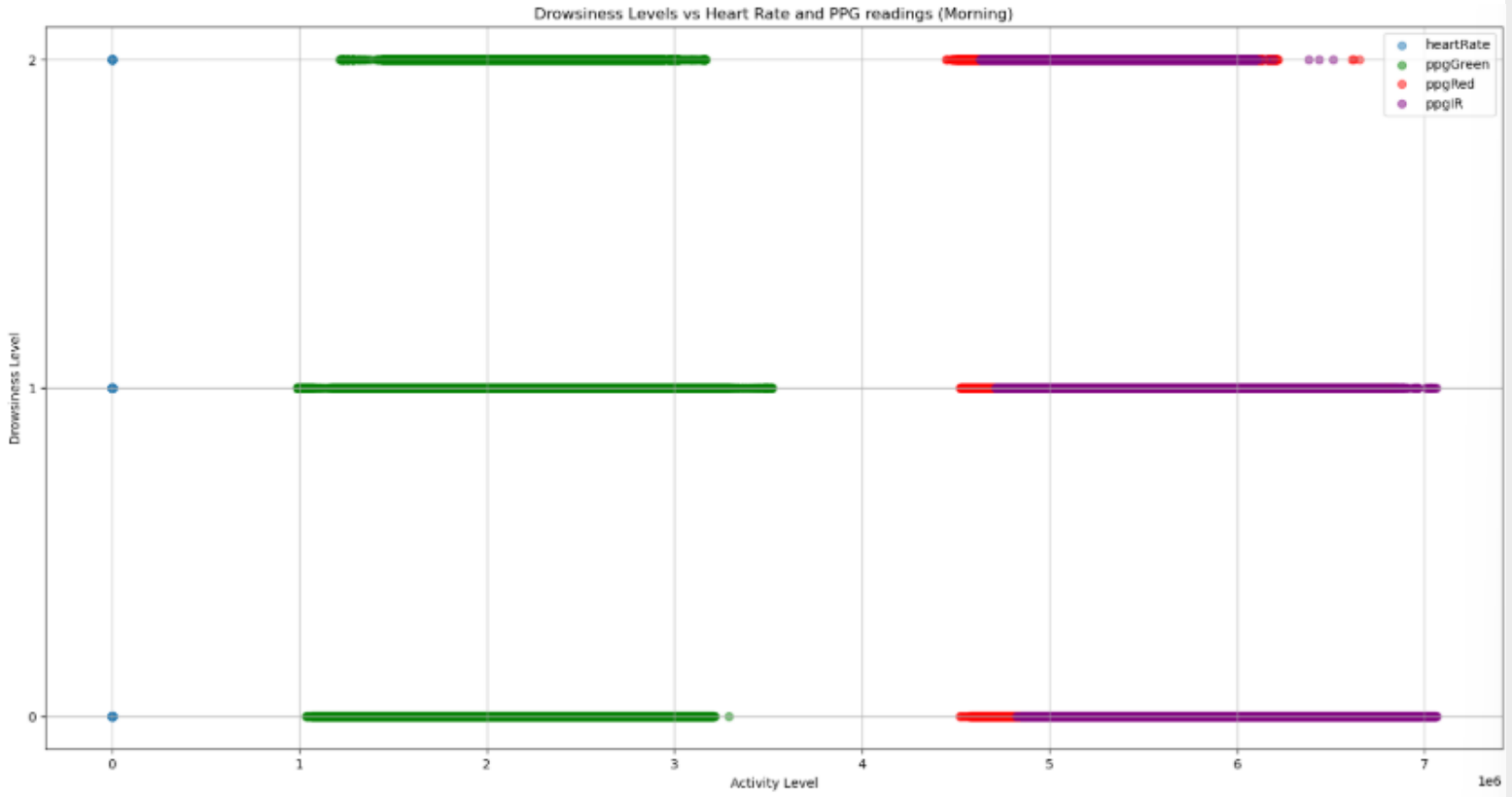


03

Key Insights:

- PPG green and red show strongest correlation with drowsiness during afternoon/night periods (0.24/0.036 respectively)
- Strong correlation between PPG red and heart rate in morning and evening periods (0.56 for both)

MORNING RELATIONSHIPS BETWEEN DROWSINESS, HEART RATE AND PPG

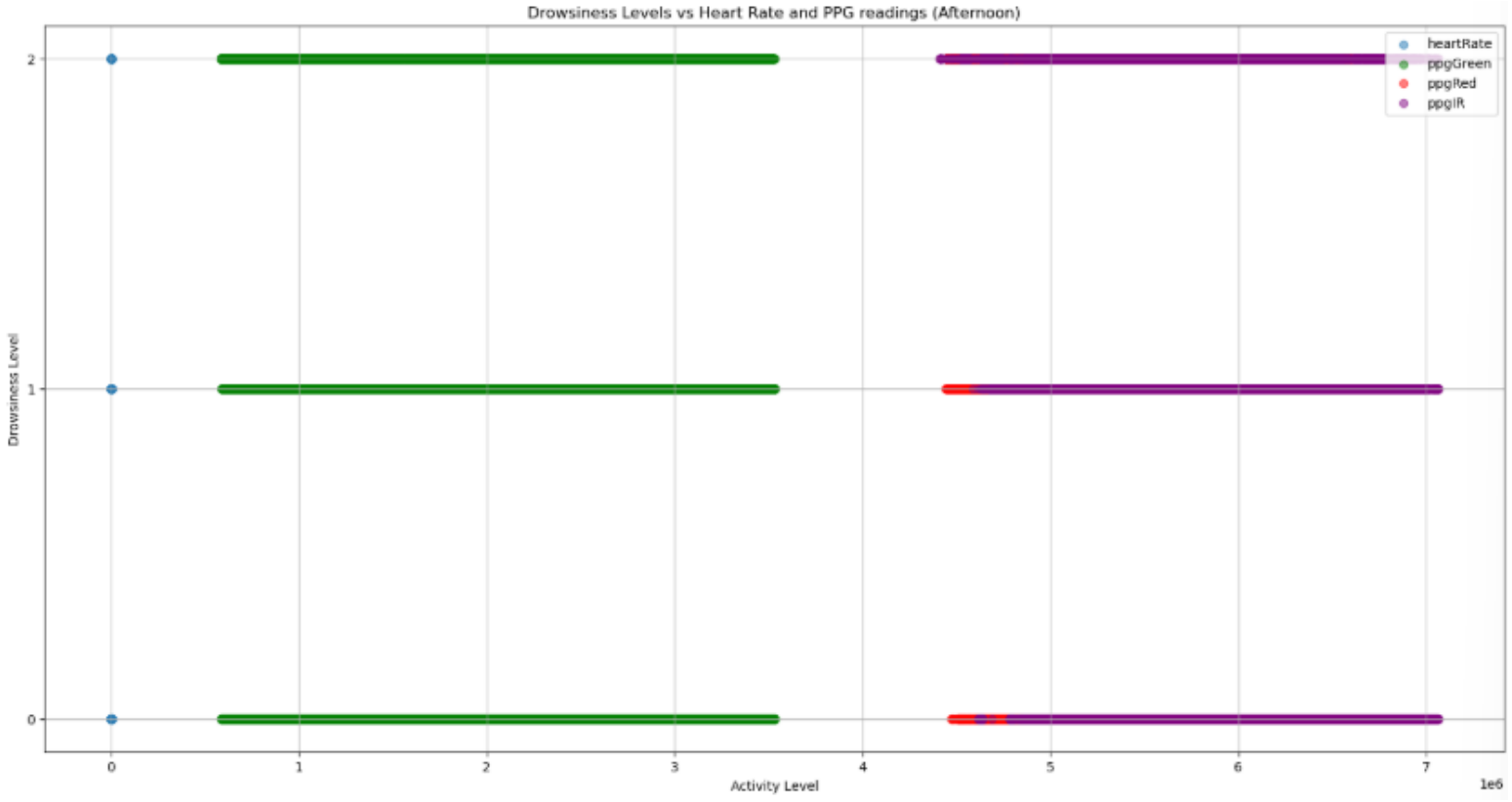


03

Key Insights:

- PPG signals and heart rate show negative correlations with drowsiness, PPG red being strongest at -0.66
- PPG Red reaches maximum value (6.8x10^6) at high level of drowsiness.
- PPG IR peaks at both medium and no drowsiness levels (7.1x10^6)

AFTERNOON RELATIONSHIPS BETWEEN DROWSINESS, HEART RATE AND PPG

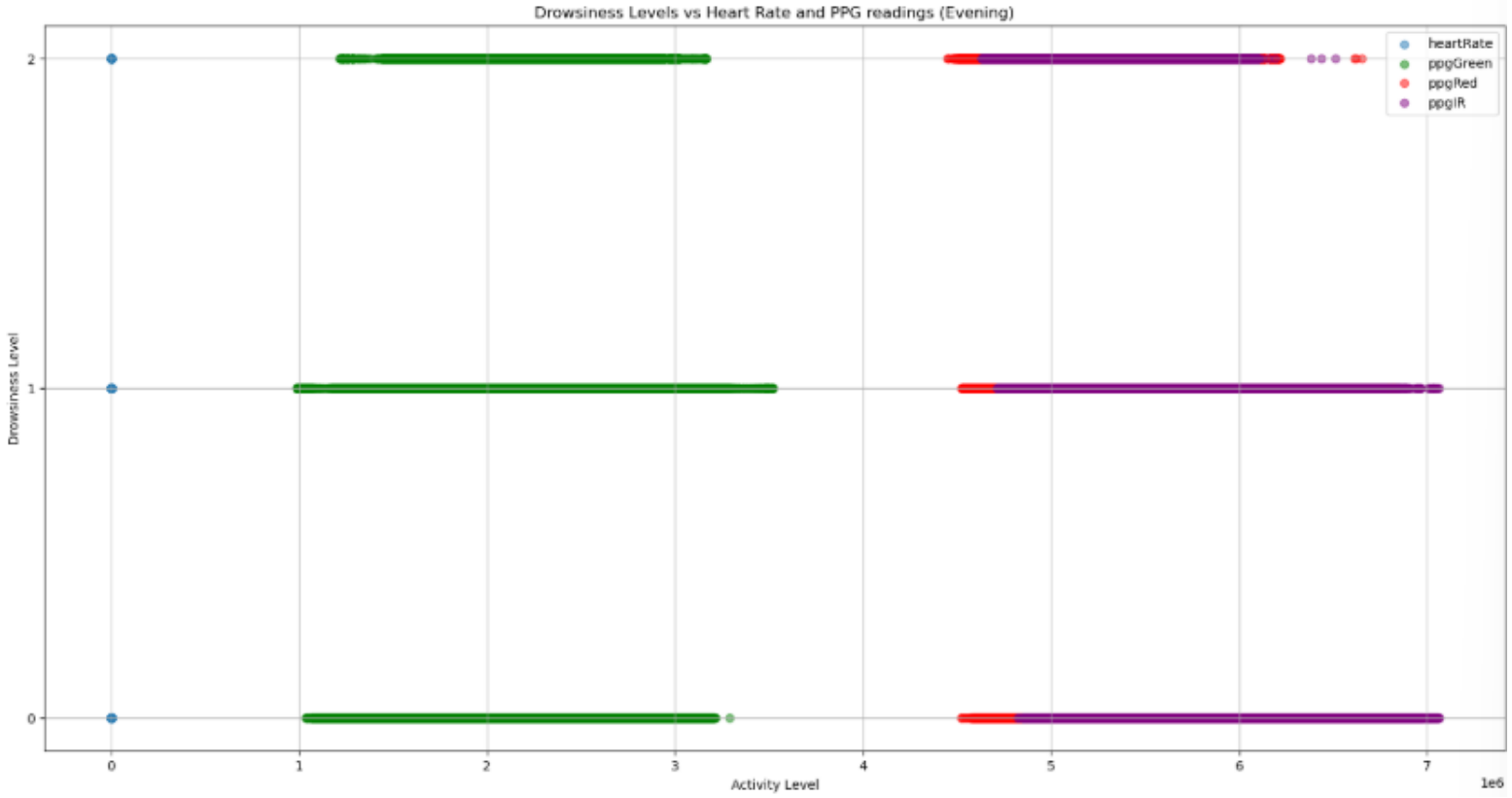


03

Key Insights:

- PPG green and PPG Red show positive correlations with drowsiness levels, with PPG Green being the strongest (0.24)
- PPG IR (-0.26) and heart rate (-0.73) have negative correlations with drowsiness

EVENING RELATIONSHIPS BETWEEN DROWSINESS, HEART RATE AND PPG

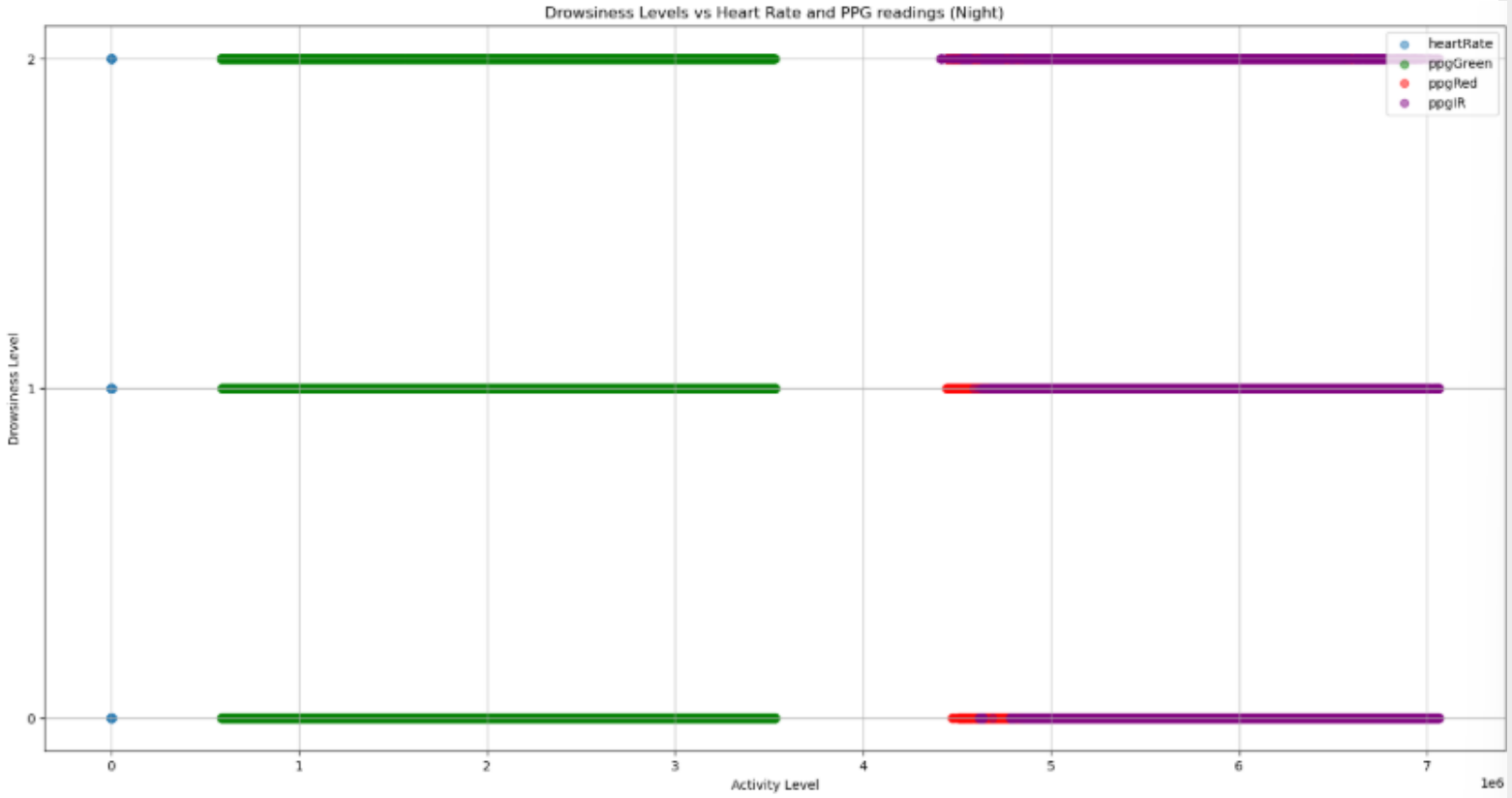


03

Key Insights:

- PPG signals and heart rate show negative correlations with drowsiness, PPG red being strongest at -0.66
- PPG Red reaches maximum value (6.8x10^6) at high level of drowsiness.

NIGHT RELATIONSHIPS BETWEEN DROWSINESS, HEART RATE AND PPG

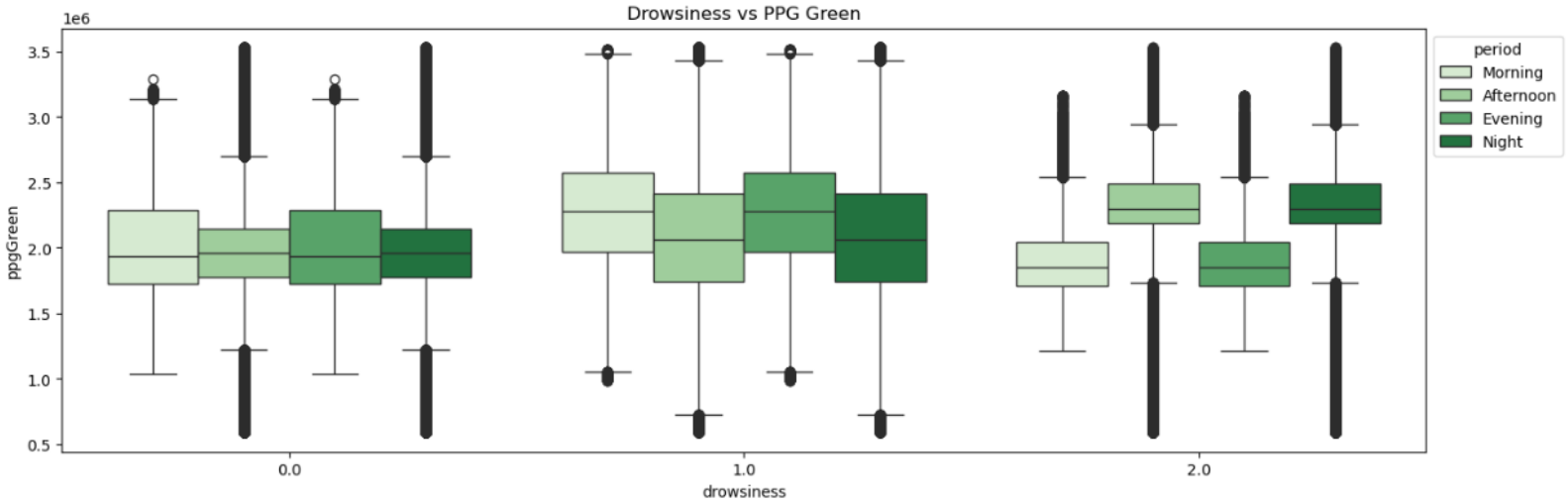


03

Key Insights:

- PPG green and PPG Red show positive correlations with drowsiness levels, with PPG Green being the strongest (0.24)
- PPG IR (-0.26) and heart rate (-0.73) have negative correlations with drowsiness

BOX PLOT ANALYSIS OF DROWSINESS AND PPG GREEN BY PERIOD

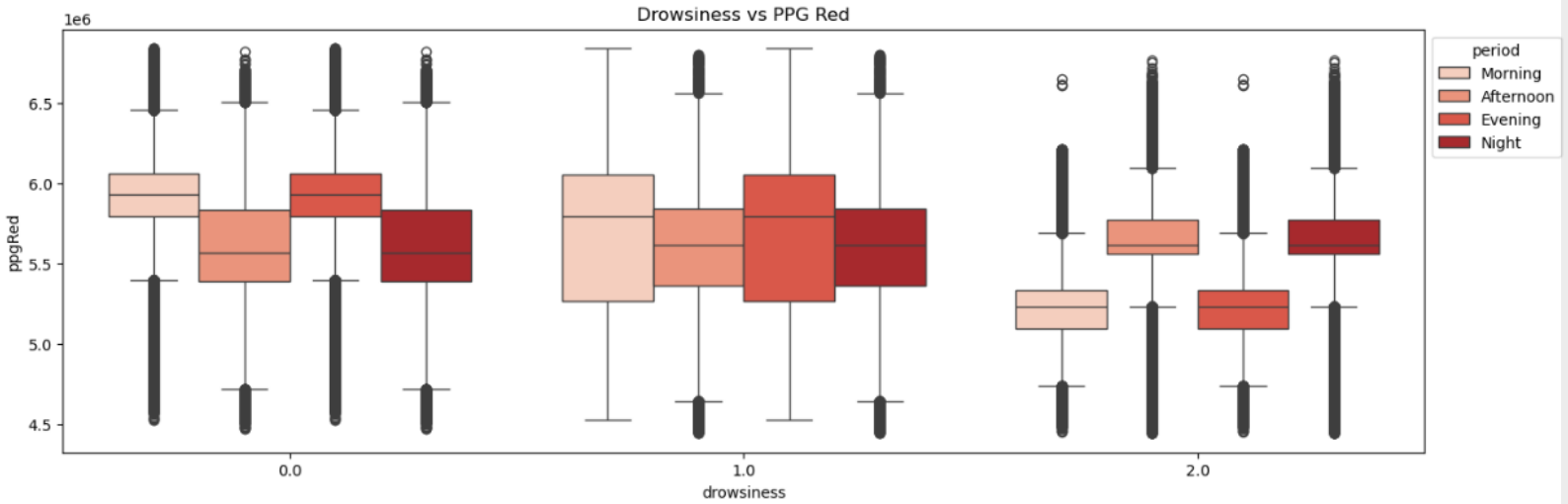


03

Key Insights:

- Most outliers in afternoon and night periods.
- Smaller IQR at higher drowsiness levels
- Median remains stable at no drowsiness, but fluctuates at medium and high levels

BOX PLOT ANALYSIS OF DROWSINESS AND PPG RED BY PERIOD

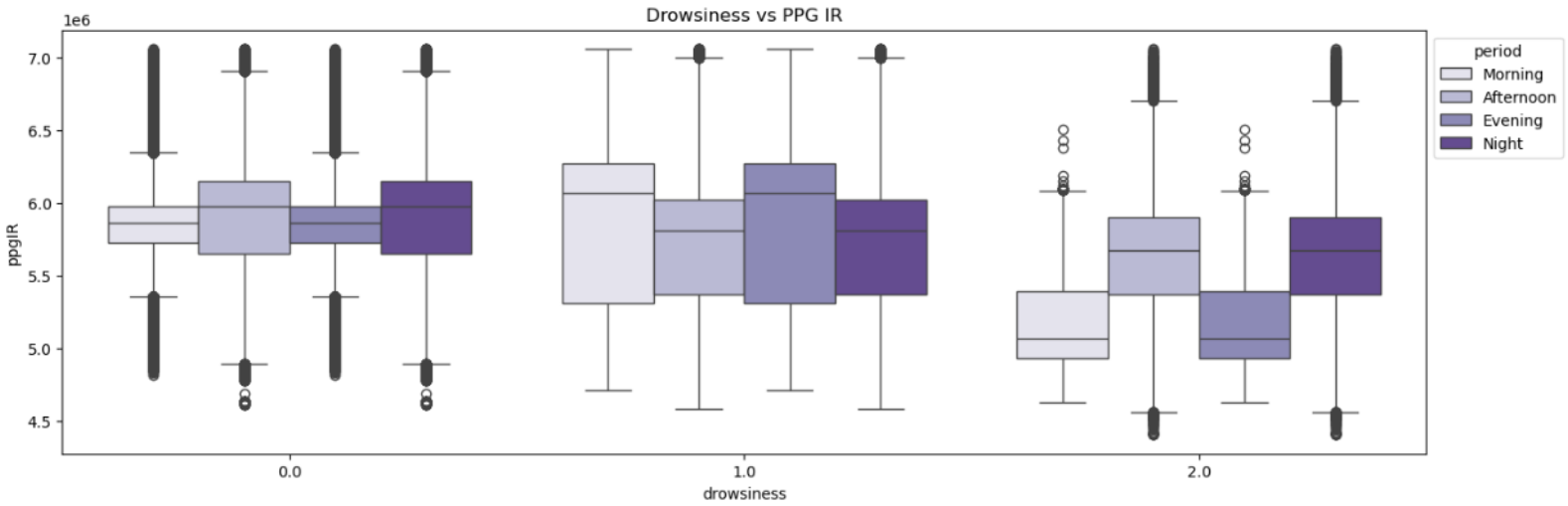


03

Key Insights:

- Significant number of outliers at no drowsiness and high drowsiness levels
- High IQR at medium level of drowsiness
- Median fluctuates across all levels of drowsiness

BOX PLOT ANALYSIS OF DROWSINESS AND PPG IR BY PERIOD

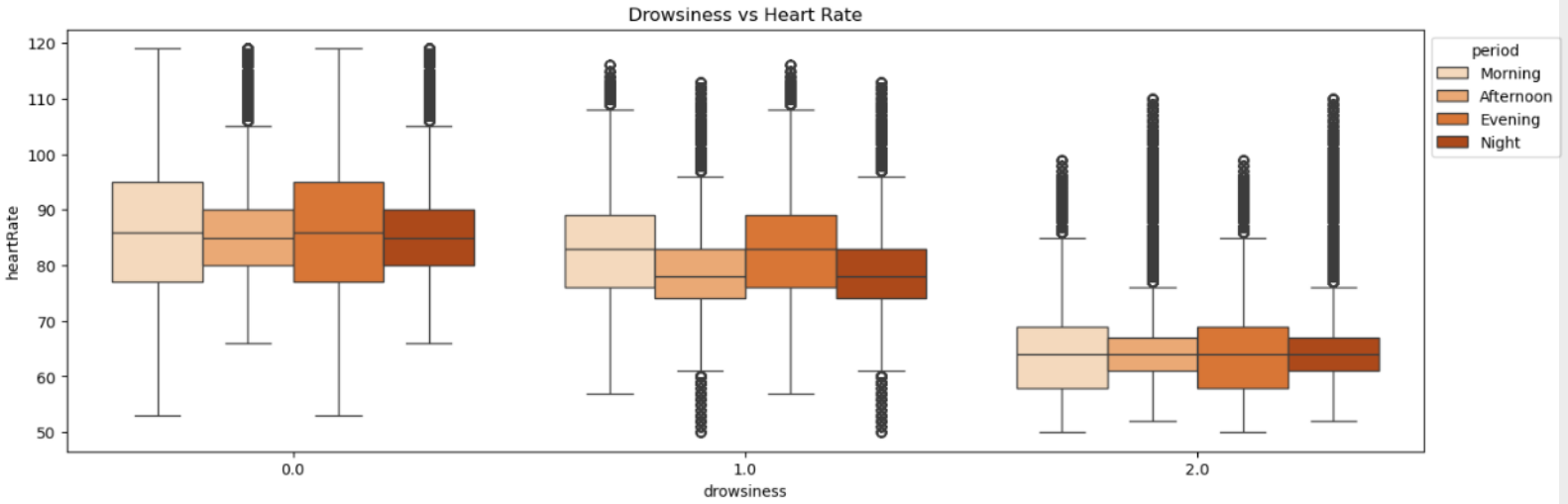


03

Key Insights:

- Significantly more outliers at no drowsiness
- High IQR at medium levels of drowsiness
- Median remains stable at no drowsiness, but fluctuates at medium and high levels

BOX PLOT ANALYSIS OF DROWSINESS AND HEART RATE BY PERIOD



03

Key Insights:

- More outliers at medium and high levels of drowsiness
- Higher IQR at morning and evening periods across all levels of drowsiness
- Median remains fairly stable across all levels of drowsiness

KEY INSIGHTS

04

- As shown in the histograms, medium and high drowsiness levels occur predominantly in the afternoon and night periods. These same periods also show the highest number of outliers for heart rate and all PPG signals in the box plots
- Drowsiness is linked to heart rates below 70 bpm, but absent above 110 bpm

- PPG green readings strongly correlate positively with drowsiness levels—both measurements rise simultaneously
- PPG green and red signals show strongest correlation with drowsiness levels during afternoon and nighttime periods
- Strong correlation between PPG red and heart rate in morning and evening periods

- For PPG green and PPG IR signals, data patterns are similar between morning/evening and afternoon/night periods
- For PPG red signals, data patterns are similar between morning/night and afternoon/evening
- PPG red and green signals show smaller IQR at high drowsiness, large IQR at medium levels, while PPG IR has high IQR at medium levels
- IQR is higher during morning and evening periods across all drowsiness levels

- Majority of outliers for PPG green signals occur during afternoon and night periods
- PPG red signals show significant number of outliers at no drowsiness and high drowsiness levels
- PPG IR signals show significantly more outliers at no drowsiness
- Overall, more outliers are present at medium and high levels of drowsiness

RECOMMENDATIONS

05

Incorporate time-of-day information
Given the higher baseline drowsiness and outlier occurrences during afternoon and night periods, incorporating other factors would improve analysis accuracy (e.g., environmental factors and task context)

Implement heart rate-based drowsiness thresholds
Since drowsiness risk increases when heart rate drops, a flexible system can adapt thresholds to each individual's typical heart patterns to detect high drowsiness levels

Integrate with Other Sensors
Consider using additional sensors like skin temperature or galvanic skin response, which have been shown to correlate with drowsiness (Kloss et al., 2014)

RECOMMENDATIONS

05

Focus on PPG Green
Since PPG green shows a stronger correlation with drowsiness, research should focus on this signal to better understand the physiological indicators of drowsiness.

Analyse PPG Red and Heart in morning/evening periods
Analyze red channel signals alongside heart rate during morning and evening hours to detect subtle drowsiness-related changes

Explore PPG signals variability
Examine the variabilities of PPG signals, where increased instability might indicate physiological instability associated with drowsiness

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