WELCOM TO OUR HEART DISEASE PREDICTION PROJECT

Milestone 1: Data Collection, Exploration, and Preprocessing

1.Data collection:

```
# Import necessary libraries
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
from sklearn.preprocessing import StandardScaler
from sklearn.impute import SimpleImputer

# Set visualization settings
sns.set_style('whitegrid')  # Set seaborn style
plt.rcParams['figure.figsize'] = (10, 6)  # Set default figure size

# 1. Load the dataset
df = pd.read_csv('heartT.csv')
df.head()
```

```
   age  sex  cp  trestbps  chol  fbs  restecg  thalach  exang  oldpeak
slope  \
0   52    1   0       125   212    0        1      168      0      1.0
2
1   53    1   0       140   203    1        0      155      1      3.1
0
2   70    1   0       145   174    0        1      125      1      2.6
0
3   61    1   0       148   203    0        1      161      0      0.0
2
4   62    0   0       138   294    1        1      106      0      1.9
1

   ca  thal  target
0   2     3       0
1   0     3       0
2   0     3       0
3   1     3       0
4   3     2       0
```

2.Data Exploration

```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 1025 entries, 0 to 1024
Data columns (total 14 columns):
 #   Column    Non-Null Count  Dtype  
---  ------    --------------  -----  
 0   age       1025 non-null   int64  
 1   sex       1025 non-null   int64  
 2   cp        1025 non-null   int64  
 3   trestbps  1025 non-null   int64  
 4   chol      1025 non-null   int64  
 5   fbs       1025 non-null   int64  
 6   restecg   1025 non-null   int64  
 7   thalach   1025 non-null   int64  
 8   exang     1025 non-null   int64  
 9   oldpeak   1025 non-null   float64
 10  slope     1025 non-null   int64  
 11  ca        1025 non-null   int64  
 12  thal      1025 non-null   int64  
 13  target    1025 non-null   int64  
dtypes: float64(1), int64(13)
memory usage: 112.2 KB
```

```
df.describe()
```

```
               age          sex           cp     trestbps        chol
\
count  1025.000000  1025.000000  1025.000000  1025.000000  1025.00000

mean     54.434146     0.695610     0.942439   131.611707   246.00000

std       9.072290     0.460373     1.029641    17.516718    51.59251

min      29.000000     0.000000     0.000000    94.000000   126.00000

25%      48.000000     0.000000     0.000000   120.000000   211.00000

50%      56.000000     1.000000     1.000000   130.000000   240.00000

75%      61.000000     1.000000     2.000000   140.000000   275.00000

max      77.000000     1.000000     3.000000   200.000000   564.00000


               fbs      restecg      thalach        exang      oldpeak
\
count  1025.000000  1025.000000  1025.000000  1025.000000  1025.000000
```

```
mean       0.149268    0.529756   149.114146    0.336585    1.071512

std        0.356527    0.527878    23.005724    0.472772    1.175053

min        0.000000    0.000000    71.000000    0.000000    0.000000

25%        0.000000    0.000000   132.000000    0.000000    0.000000

50%        0.000000    1.000000   152.000000    0.000000    0.800000

75%        0.000000    1.000000   166.000000    1.000000    1.800000

max        1.000000    2.000000   202.000000    1.000000    6.200000
```

```
             slope           ca         thal       target
count  1025.000000  1025.000000  1025.000000  1025.000000
mean      1.385366     0.754146     2.323902     0.513171
std       0.617755     1.030798     0.620660     0.500070
min       0.000000     0.000000     0.000000     0.000000
25%       1.000000     0.000000     2.000000     0.000000
50%       1.000000     0.000000     2.000000     1.000000
75%       2.000000     1.000000     3.000000     1.000000
max       2.000000     4.000000     3.000000     1.000000
```

```
df.shape
```

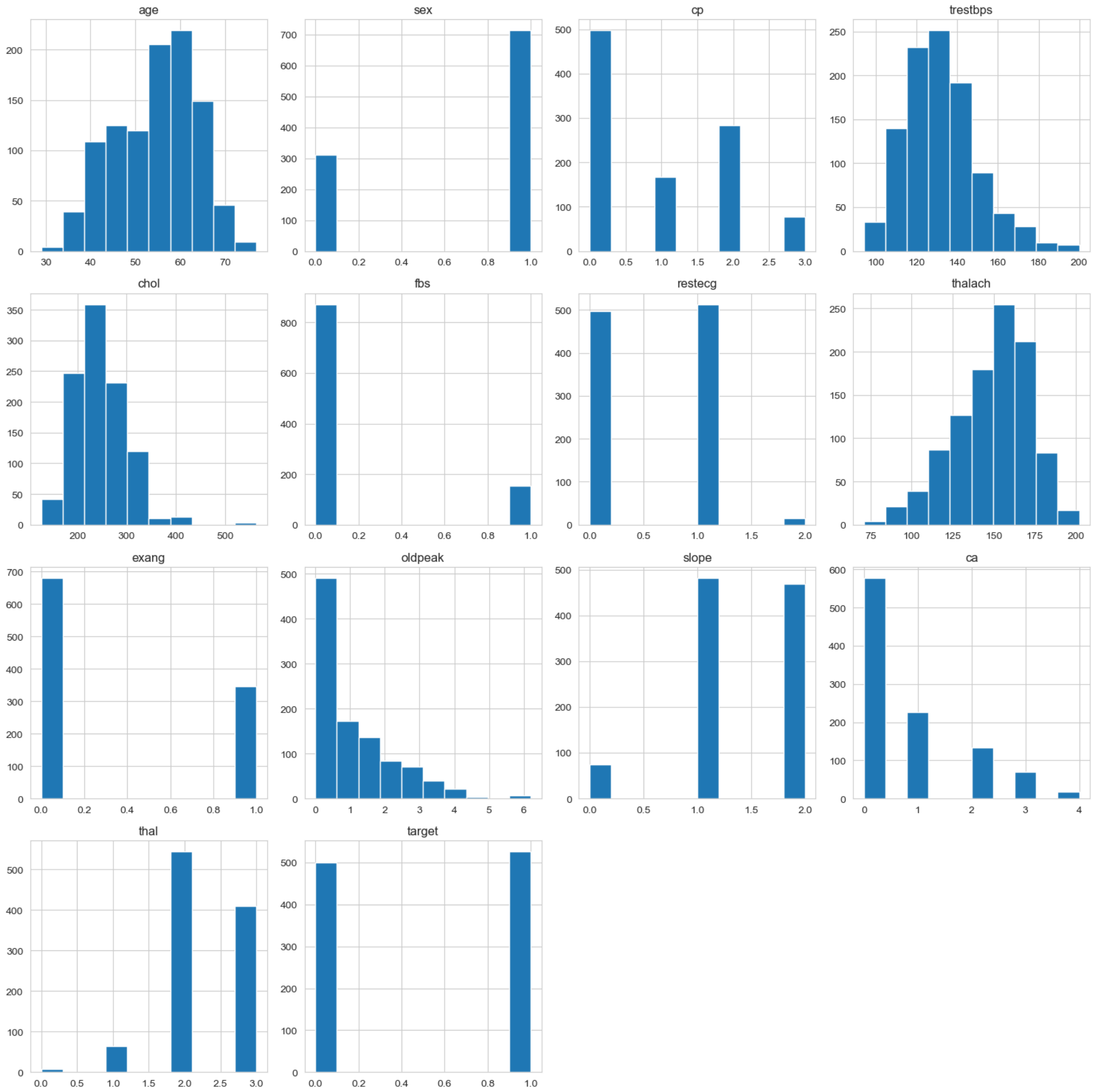
```
(1025, 14)
```

```
# Check for missing values in each column
df.isnull().sum()
```

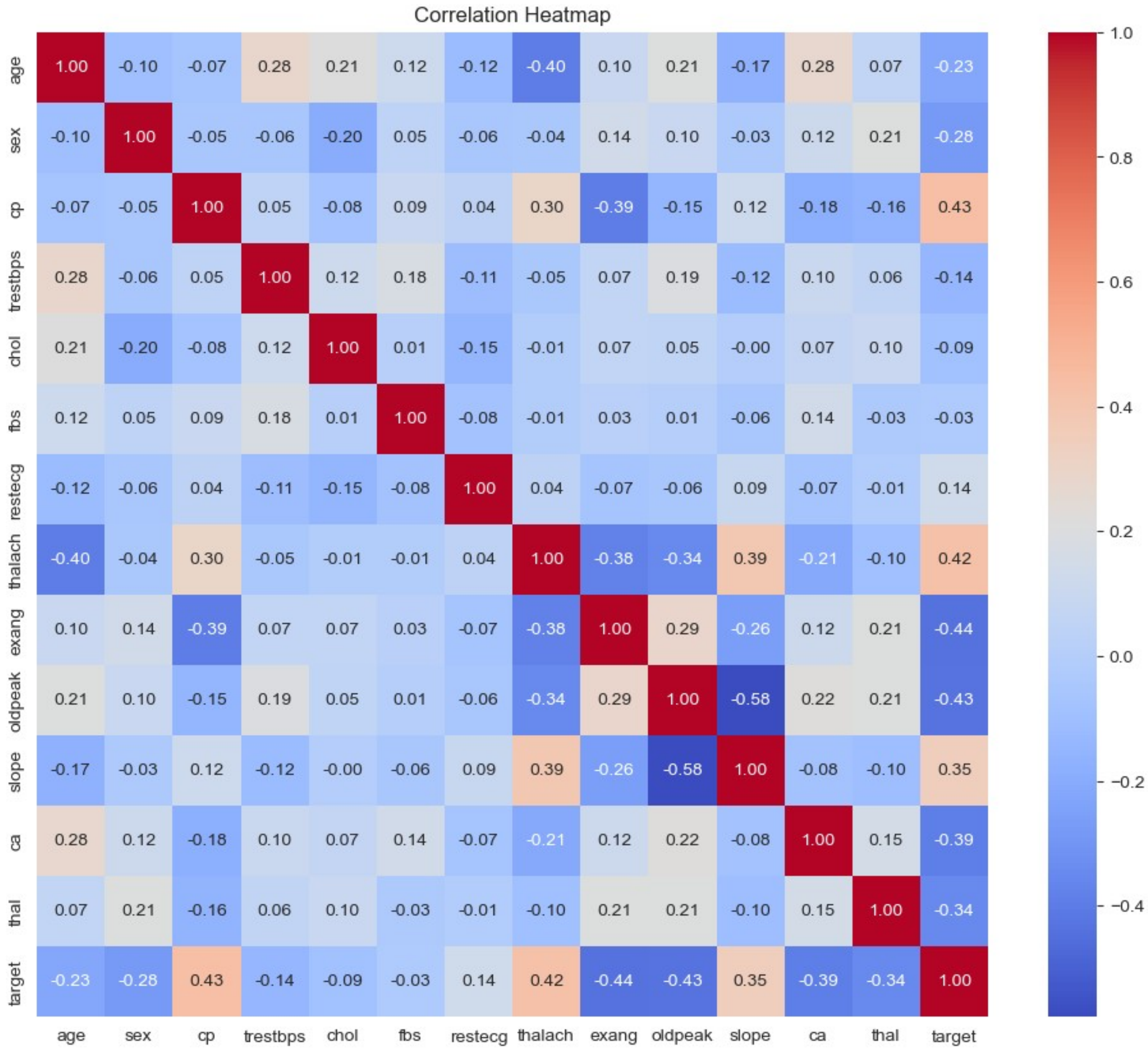
```
age         0
sex         0
cp          0
trestbps    0
chol        0
fbs         0
restecg     0
thalach     0
exang       0
oldpeak     0
slope       0
ca          0
thal        0
target      0
dtype: int64
```

```
# Plot histograms for all numerical variables to see their 
distributions
df.hist(figsize=(15, 15))
```

```
plt.tight_layout()  # Adjust layout to prevent overlapping
plt.show()
```



```
numeric_cols = df.select_dtypes(include=['int64',
'float64']).columns.tolist()
# Plot heatmap for correlation matrix
plt.figure(figsize=(12,10))
corr = df[numeric_cols].corr()
sns.heatmap(corr, annot=True, cmap='coolwarm', fmt=".2f")
plt.title('Correlation Heatmap')
plt.show()
```



3.Data preprocessing

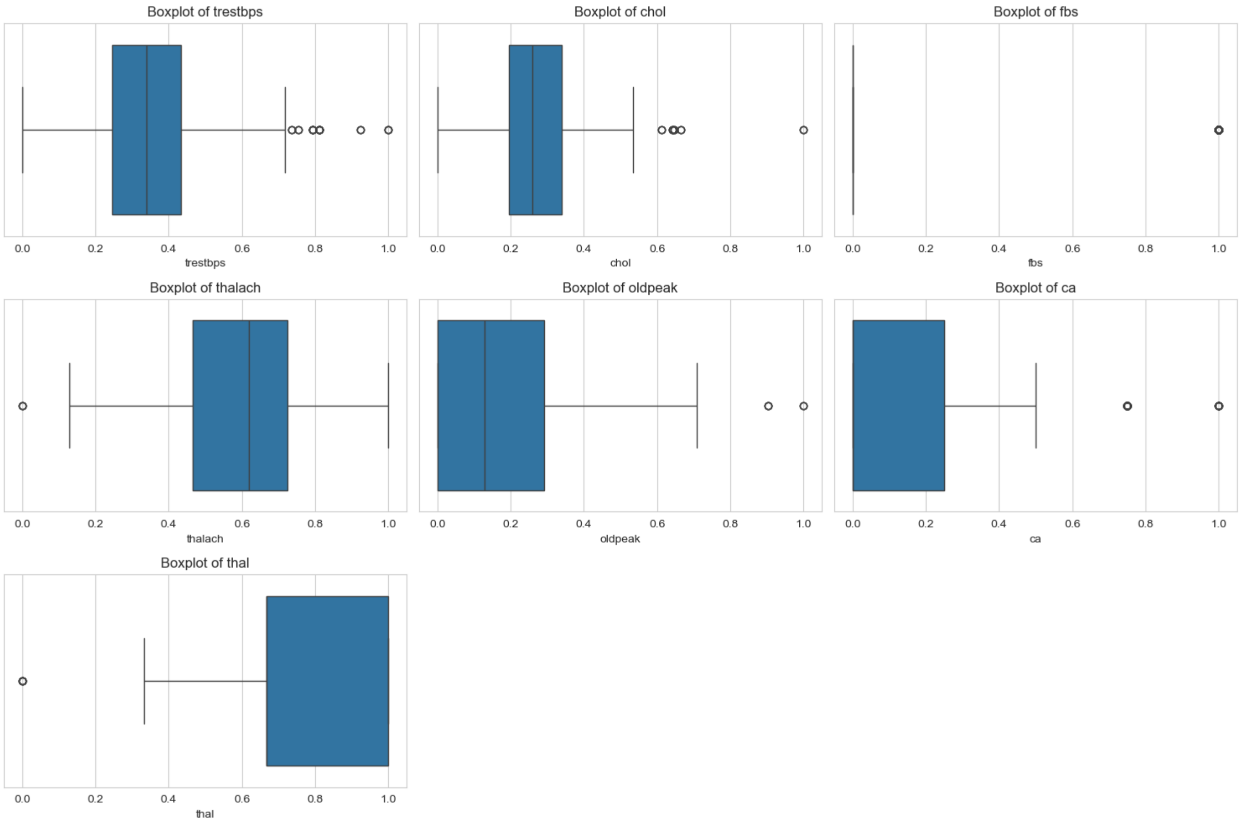
```
from sklearn.preprocessing import MinMaxScaler

scaler = MinMaxScaler()
df[numeric_cols] = scaler.fit_transform(df[numeric_cols])

df.head()

        age  sex   cp  trestbps      chol  fbs  restecg   thalach
exang  \
0  0.479167  1.0  0.0  0.292453  0.196347  0.0      0.5  0.740458
0.0
1  0.500000  1.0  0.0  0.433962  0.175799  1.0      0.0  0.641221
1.0
2  0.854167  1.0  0.0  0.481132  0.109589  0.0      0.5  0.412214
```

```
1.0
3  0.666667  1.0  0.0  0.509434  0.175799  0.0      0.5  0.687023
0.0
4  0.687500  0.0  0.0  0.415094  0.383562  1.0      0.5  0.267176
0.0

    oldpeak  slope    ca      thal  target
0  0.161290    1.0  0.50  1.000000     0.0
1  0.500000    0.0  0.00  1.000000     0.0
2  0.419355    0.0  0.00  1.000000     0.0
3  0.000000    1.0  0.25  1.000000     0.0
4  0.306452    0.5  0.75  0.666667     0.0
```

Milestone 2: Data Analysis and Visualization

1. Outliers detection and handling

```python
import matplotlib.pyplot as plt
import seaborn as sns

# List of columns with outliers
cols_with_outliers = ['trestbps', 'chol', 'fbs', 'thalach', 'oldpeak',
'ca', 'thal']

# Plot boxplots for each column with outliers
plt.figure(figsize=(15, 10))
for i, col in enumerate(cols_with_outliers, 1):
    plt.subplot(3, 3, i)
    sns.boxplot(data=df, x=col)
    plt.title(f'Boxplot of {col}')
plt.tight_layout()
plt.show()
```



```
import pandas as pd

# List of columns with outliers to remove
cols_with_outliers = ['trestbps', 'chol', 'fbs', 'thalach', 'oldpeak',
'ca', 'thal']

def remove_outliers_iqr(df, column):
    Q1 = df[column].quantile(0.25)
    Q3 = df[column].quantile(0.75)
    IQR = Q3 - Q1
    lower_bound = Q1 - 1.5 * IQR
    upper_bound = Q3 + 1.5 * IQR

    # Keep rows within the bounds
    return df[(df[column] >= lower_bound) & (df[column] <=
upper_bound)]

df_clean = df.copy()

# Loop over columns and iteratively remove outliers
for col in cols_with_outliers:
    df_clean = remove_outliers_iqr(df_clean, col)

print(df_clean.skew(numeric_only=True))
```

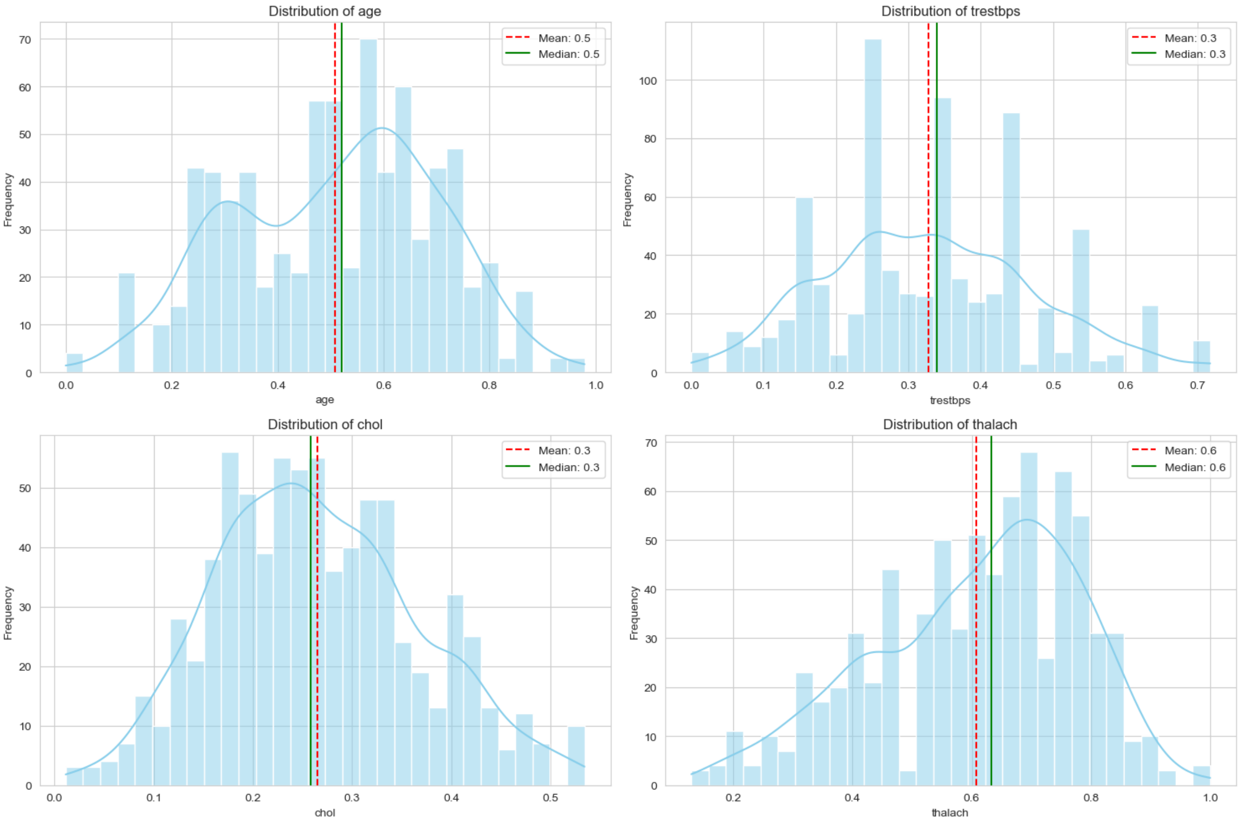
```
age        -0.177371
sex        -0.832416
cp          0.580705
trestbps    0.276280
chol        0.266805
fbs         0.000000
restecg    -0.006654
thalach    -0.482755
exang       0.754599
oldpeak     0.944266
slope      -0.503237
ca          1.075802
thal       -0.143249
target     -0.196376
dtype: float64
```

```python
import numpy as np
df_clean['ca' + '_log'] = np.log1p(df_clean['ca'])
```

```python
print(df_clean.skew(numeric_only=True))
```

```
age        -0.177371
sex        -0.832416
cp          0.580705
trestbps    0.276280
chol        0.266805
fbs         0.000000
restecg    -0.006654
thalach    -0.482755
exang       0.754599
oldpeak     0.944266
slope      -0.503237
ca          1.075802
thal       -0.143249
target     -0.196376
ca_log      0.950673
dtype: float64
```

```python
# Select numerical columns
numerical_cols = ['age','trestbps', 'chol' , 'thalach']


# Plot histograms and KDE for each numerical column
plt.figure(figsize=(15, 10))
for i, col in enumerate(numerical_cols, 1):
    plt.subplot(2, 2, i)

    # Histogram with KDE
    sns.histplot(df_clean[col], kde=True, color='skyblue', bins=30)
    plt.title(f'Distribution of {col}')
    plt.xlabel(col)
    plt.ylabel('Frequency')

    # Mark mean/median for reference"
    mean_val = df_clean[col].mean()
    median_val = df_clean[col].median()
    plt.axvline(mean_val, color='red', linestyle='--', label=f'Mean: 
{mean_val:.1f}')
    plt.axvline(median_val, color='green', linestyle='-', 
label=f'Median: {median_val:.1f}')
    plt.legend()

plt.tight_layout()
plt.show()
```



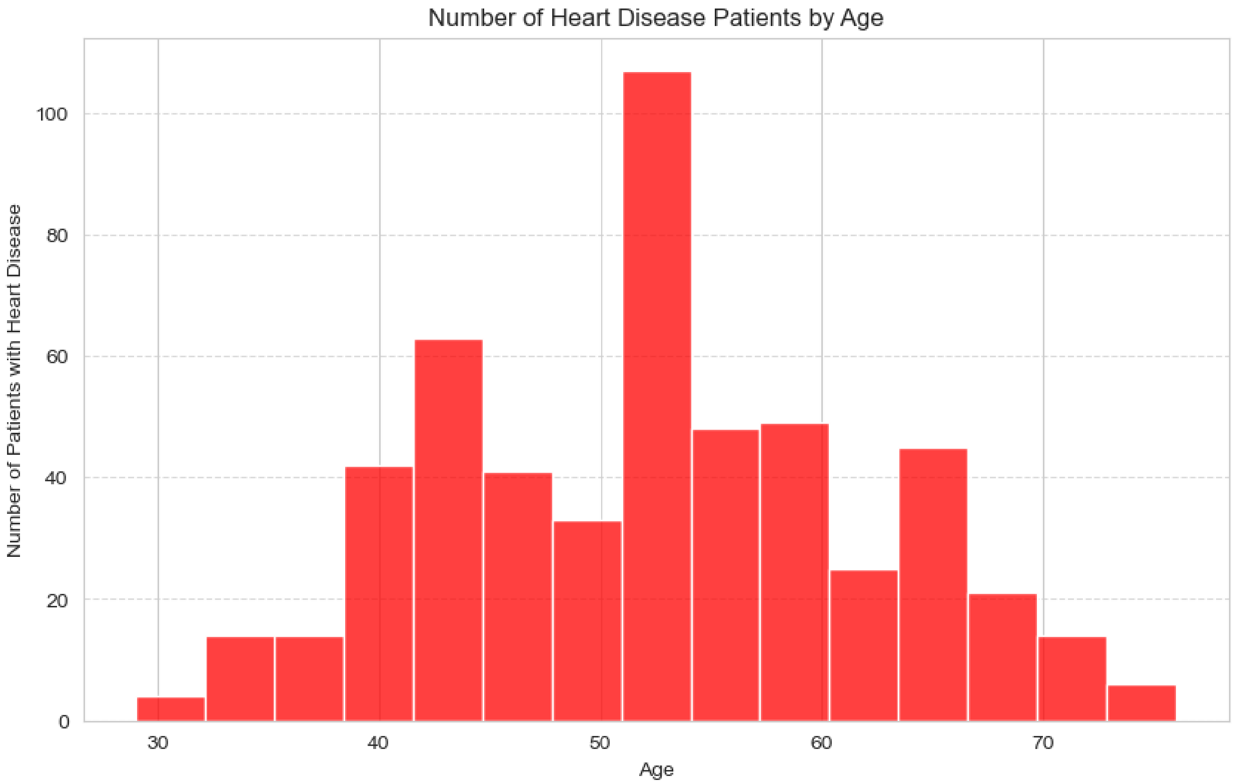
```
df_clean.head()
```

```
        age  sex   cp  trestbps      chol  fbs  restecg   thalach  
exang  \
0  0.479167  1.0  0.0  0.292453  0.196347  0.0      0.5  0.740458  
0.0   
2  0.854167  1.0  0.0  0.481132  0.109589  0.0      0.5  0.412214  
1.0   
3  0.666667  1.0  0.0  0.509434  0.175799  0.0      0.5  0.687023  
```

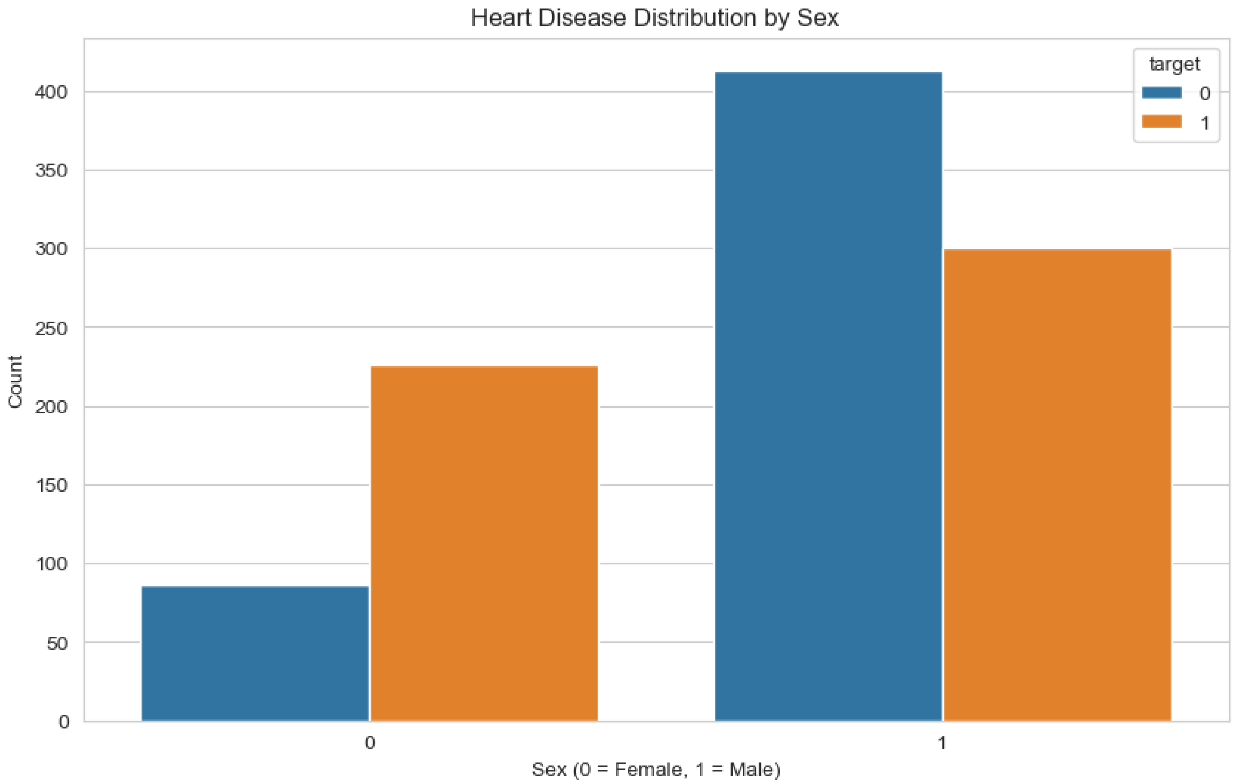
```
0.0
5  0.604167  0.0  0.0  0.056604  0.278539  0.0      0.0  0.389313
0.0
7  0.541667  1.0  0.0  0.622642  0.372146  0.0      0.0  0.564885
1.0

    oldpeak  slope    ca      thal  target    ca_log
0  0.161290    1.0  0.50  1.000000     0.0  0.405465
2  0.419355    0.0  0.00  1.000000     0.0  0.000000
3  0.000000    1.0  0.25  1.000000     0.0  0.223144
5  0.161290    0.5  0.00  0.666667     1.0  0.000000
7  0.129032    0.5  0.25  1.000000     0.0  0.223144
```

Data Visualization

```python
import matplotlib.pyplot as plt
import seaborn as sns

# Filter data for heart disease patients only
heart_disease_patients = df[df['target'] == 1]

# Create histogram
plt.figure(figsize=(10, 6))
sns.histplot(data=heart_disease_patients, x='age', bins=15, kde=False, 
color='red')
plt.title('Number of Heart Disease Patients by Age')
plt.xlabel('Age')
plt.ylabel('Number of Patients with Heart Disease')
plt.grid(axis='y', linestyle='--', alpha=0.7)
plt.show()
```



```python
import seaborn as sns
import matplotlib.pyplot as plt

# Plot count of target per sex
sns.countplot(x='sex', hue='target', data=df)
plt.title('Heart Disease Distribution by Sex')
plt.xlabel('Sex (0 = Female, 1 = Male)')
plt.ylabel('Count')
plt.show()
```

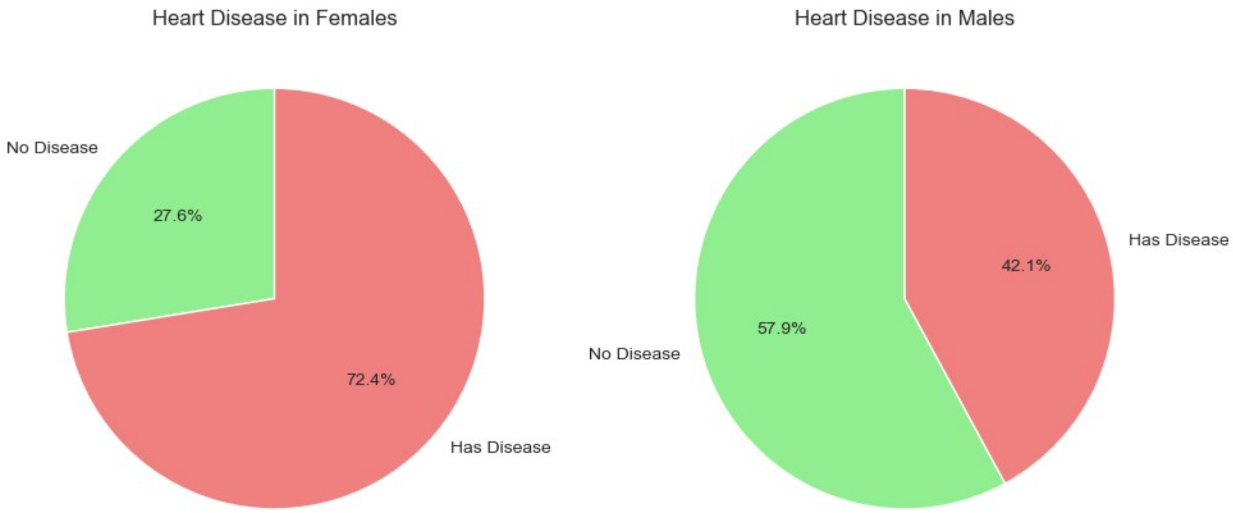


```
# Group data by sex and calculate the sum of target (heart disease
cases) for each sex
disease_counts = df.groupby('sex')['target'].sum()

# Print the number of females (sex=0) and males (sex=1) who have heart
disease
print("Number of females with heart disease:", disease_counts[0])
print("Number of males with heart disease:", disease_counts[1])
```

```
Number of females with heart disease: 226
Number of males with heart disease: 300
```

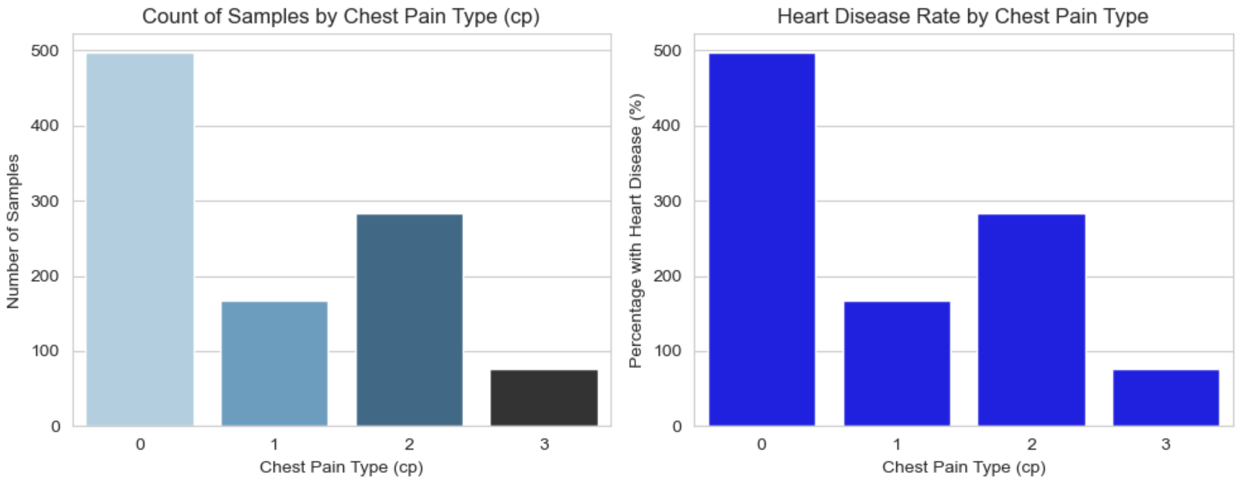
```
import matplotlib.pyplot as plt

# Count of target for each sex
female_counts = df[df['sex'] == 0]
['target'].value_counts().sort_index()
male_counts = df[df['sex'] == 1]['target'].value_counts().sort_index()

# Labels and colors
labels = ['No Disease', 'Has Disease']
colors = ['lightgreen', 'lightcoral']

# Create subplots
fig, axes = plt.subplots(1, 2, figsize=(10, 5))
```

```python
# Female pie chart
axes[0].pie(female_counts, labels=labels, autopct='%1.1f%%',
colors=colors, startangle=90)
axes[0].set_title('Heart Disease in Females')

# Male pie chart
axes[1].pie(male_counts, labels=labels, autopct='%1.1f%%',
colors=colors, startangle=90)
axes[1].set_title('Heart Disease in Males')

plt.tight_layout()
plt.show()
```



```python
# Count samples per cp type
cp_counts = df['cp'].value_counts().sort_index()
print("Samples count per cp type:")
print(cp_counts)

# Calculate heart disease rate per cp type
cp_heart_disease_rate = df.groupby('cp')['target'].mean() * 100

print("\nHeart disease rate per cp type (%):")
print(cp_heart_disease_rate)

# Plot count of samples per cp type
plt.figure(figsize=(10, 4))
plt.subplot(1, 2, 1)
sns.barplot(x=cp_counts.index, y=cp_counts.values, palette='Blues_d',
hue=cp_counts.index, legend=False)

plt.title('Count of Samples by Chest Pain Type (cp)')
plt.xlabel('Chest Pain Type (cp)')
plt.ylabel('Number of Samples')

# Plot heart disease rate per cp type
plt.subplot(1, 2, 2)
sns.barplot(x=cp_counts.index, y=cp_counts.values, color='blue')
plt.title('Heart Disease Rate by Chest Pain Type')
plt.xlabel('Chest Pain Type (cp)')
plt.ylabel('Percentage with Heart Disease (%)')

plt.tight_layout()
plt.show()
```

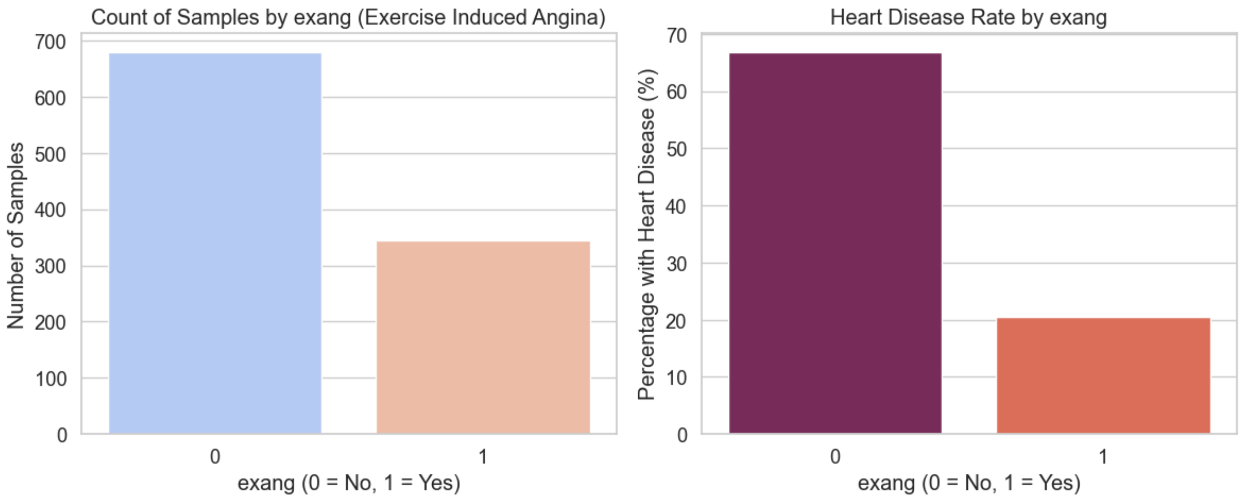
```
Samples count per cp type:
cp
0    497
1    167
2    284
3     77
Name: count, dtype: int64

Heart disease rate per cp type (%):
cp
0    24.547284
1    80.239521
2    77.112676
3    66.233766
Name: target, dtype: float64
```



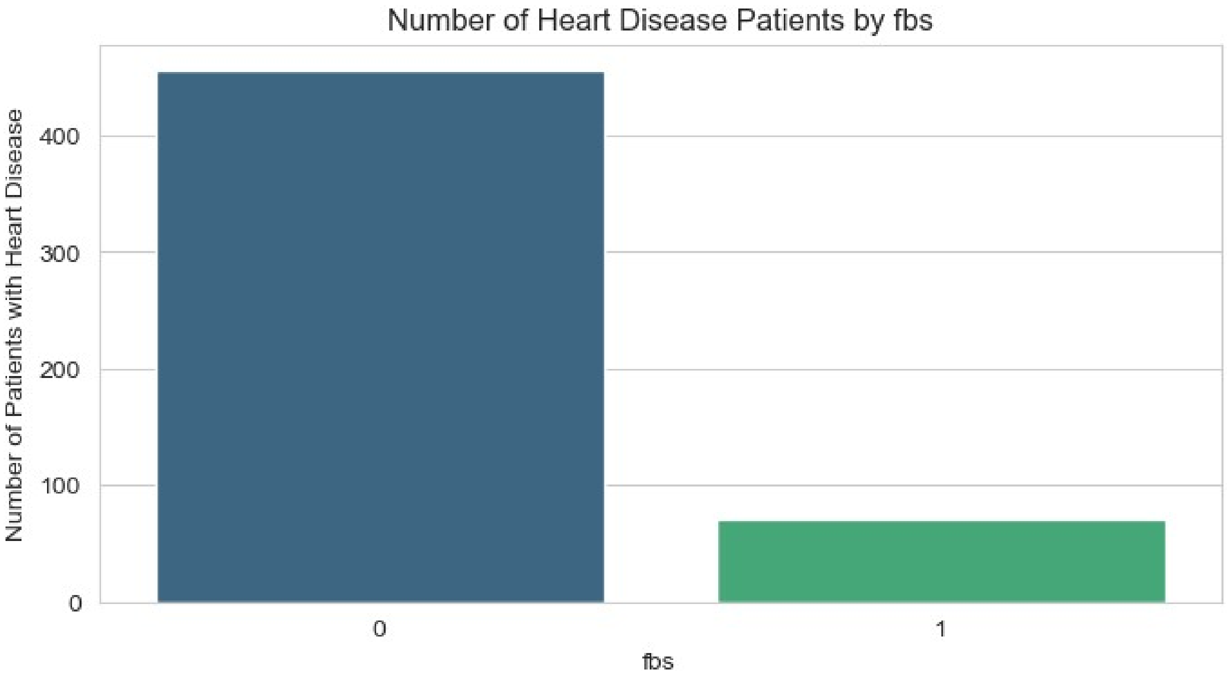
```
import matplotlib.pyplot as plt
import seaborn as sns

# Calculate heart disease rate by exang
exang_counts = df['exang'].value_counts()
exang_heart_disease_rate = df.groupby('exang')['target'].mean() * 100
```

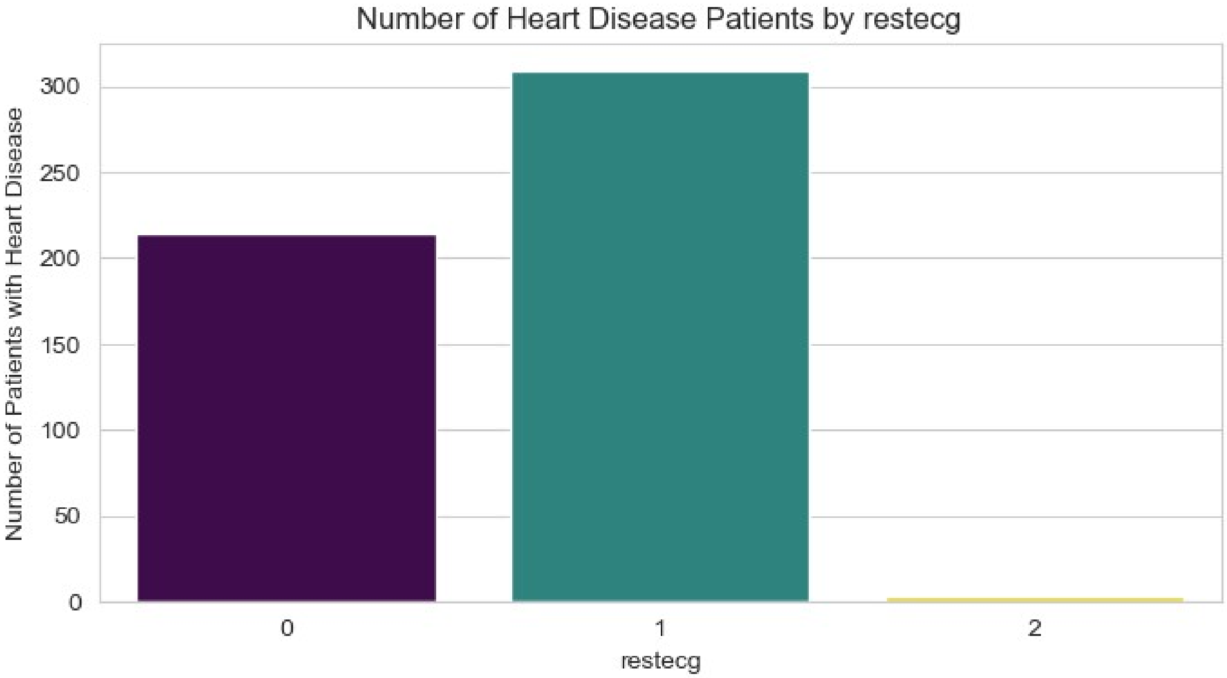
```
print("Samples count per exang value:")
print(exang_counts)

print("\nHeart disease rate by exang value (%):")
print(exang_heart_disease_rate)

# Plot for exang
plt.figure(figsize=(12, 5))

plt.subplot(1, 2, 1)
sns.barplot(x=exang_counts.index, y=exang_counts.values,
palette='coolwarm')
plt.title('Count of Samples by exang (Exercise Induced Angina)')
plt.xlabel('exang (0 = No, 1 = Yes)')
plt.ylabel('Number of Samples')

plt.subplot(1, 2, 2)
sns.barplot(x=exang_heart_disease_rate.index,
y=exang_heart_disease_rate.values, palette='rocket')
plt.title('Heart Disease Rate by exang')
plt.xlabel('exang (0 = No, 1 = Yes)')
plt.ylabel('Percentage with Heart Disease (%)')

plt.tight_layout()
plt.show()
```

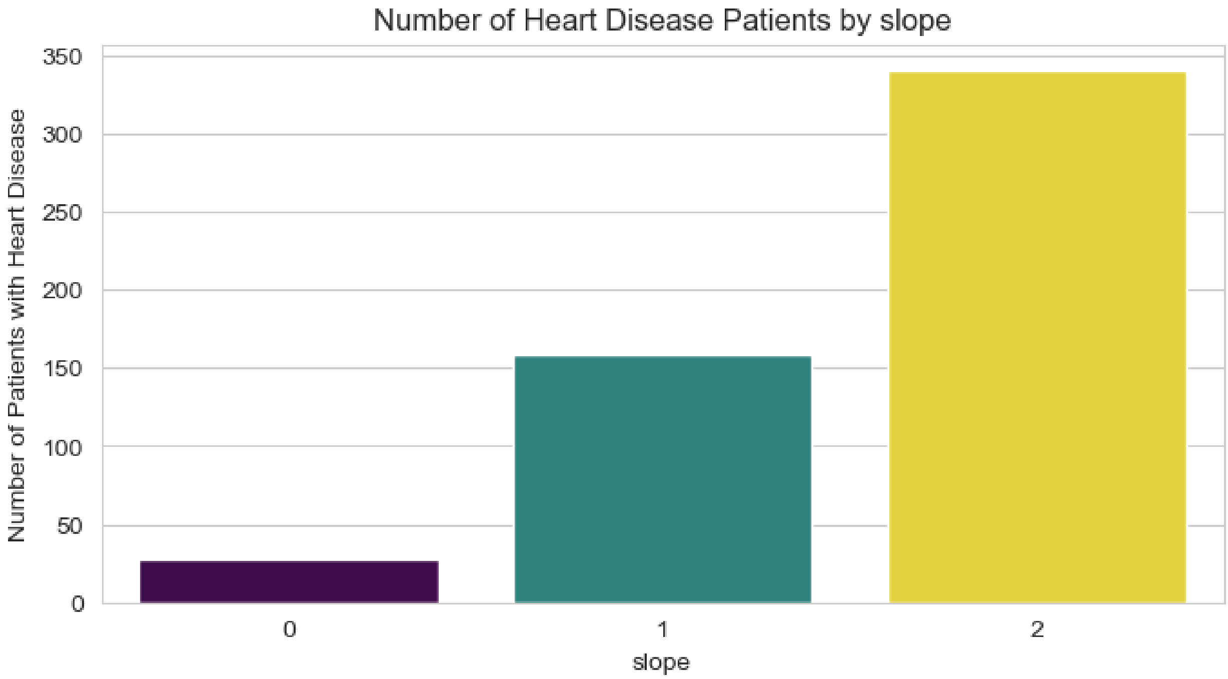
```
Samples count per exang value:
exang
0    680
1    345
Name: count, dtype: int64

Heart disease rate by exang value (%):
exang
0    66.911765
1    20.579710
Name: target, dtype: float64
```

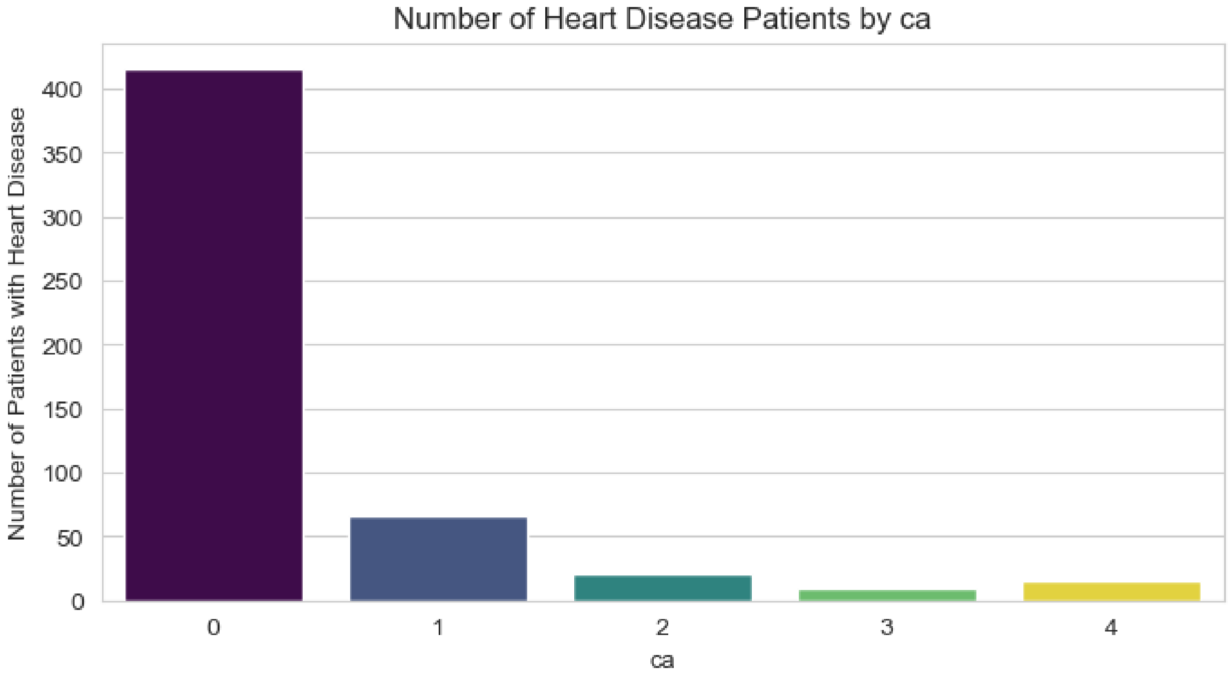


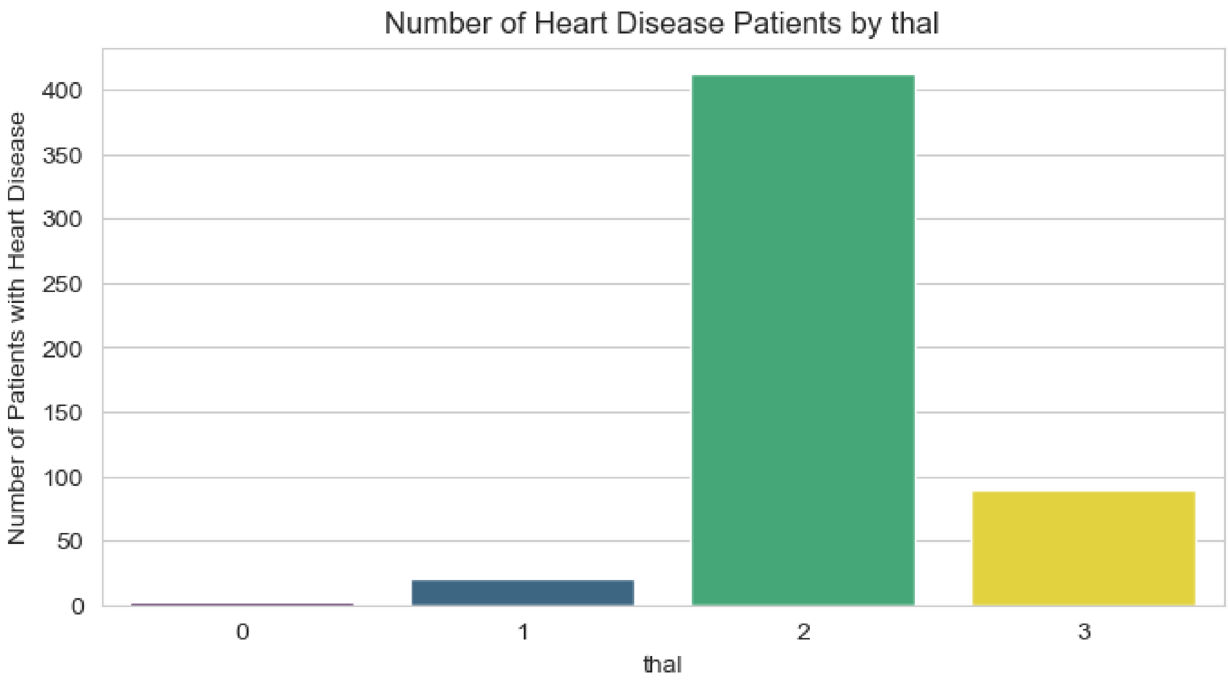
```
columns_to_plot = [ 'fbs', 'restecg', 'slope', 'ca', 'thal']

for col in columns_to_plot:
    plt.figure(figsize=(8,4))

    # Group by column value and sum target (number of patients with
heart disease)
    data_plot = df.groupby(col)['target'].sum().reset_index()

    sns.barplot(x=col, y='target', data=data_plot, hue=col,
palette='viridis', legend=False)
    plt.title(f'Number of Heart Disease Patients by {col}')
    plt.ylabel('Number of Patients with Heart Disease')
    plt.xlabel(col)
    plt.show()
```


Number of Heart Disease Patients by fbs
Number of Patients with Heart Disease
0
100
200
300
400
0
1
fbs


Number of Heart Disease Patients by restecg
Number of Patients with Heart Disease
0
50
100
150
200
250
300
0
1
2
restecg


Number of Heart Disease Patients by slope
Number of Patients with Heart Disease
0
50
100
150
200
250
300
350
0
1
2
slope


Number of Heart Disease Patients by ca
Number of Patients with Heart Disease
0
50
100
150
200
250
300
350
400
0
1
2
3
4
ca



Age group dashboard

```
import pandas as pd
from dash import Dash, dcc, html
import plotly.express as px

# Load your dataset CSV file (adjust path as needed)
df = pd.read_csv('heart.csv')

# Example: If you don't have an 'age_group' column,
# create it by binning the 'age' column
bins = [25, 34, 44, 54, 64, 79]
labels = ['25-34', '35-44', '45-54', '55-64', '65-79']
df['age_group'] = pd.cut(df['age'], bins=bins, labels=labels,
right=True, include_lowest=True)

# Count number of patients per age group
age_group_counts = df['age_group'].value_counts().sort_index()
age_group_df = age_group_counts.reset_index()
age_group_df.columns = ['age_group', 'patient_count']

# Create the Dash app
app = Dash(__name__)

# Create bar chart of patient count by age group
fig = px.bar(
    age_group_df,
    x='age_group',
    y='patient_count',
    title='Number of Patients per Age Group',
    labels={'age_group': 'Age Group', 'patient_count': 'Number of
Patients'},
    template='plotly_white'
)

# Layout
app.layout = html.Div(children=[
    html.H1('Patient Count by Age Group Dashboard'),
    dcc.Graph(id='patient-count-bar', figure=fig)
])

if __name__ == '__main__':
    app.run_server(debug=True)

<IPython.lib.display.IFrame at 0x2520803de20>
```

Milestone 3: Predictive Model Development and Optimization

```
# Calculate correlation of all columns with 'target'
correlations = df_clean.corr()['target'].abs()

# Filter correlations with absolute value greater than 0.3
filtered_corr = correlations[correlations.abs() > 0.3]

# Sort the filtered correlations by absolute value in descending order
filtered_corr = filtered_corr.sort_values(key=abs, ascending=False)

# Print the filtered correlations
print(filtered_corr)

target      1.000000
ca_log      0.464166
ca          0.456208
thal        0.454862
oldpeak     0.443599
thalach     0.416945
exang       0.416859
cp          0.374184
sex         0.367541
slope       0.319420
Name: target, dtype: float64
```

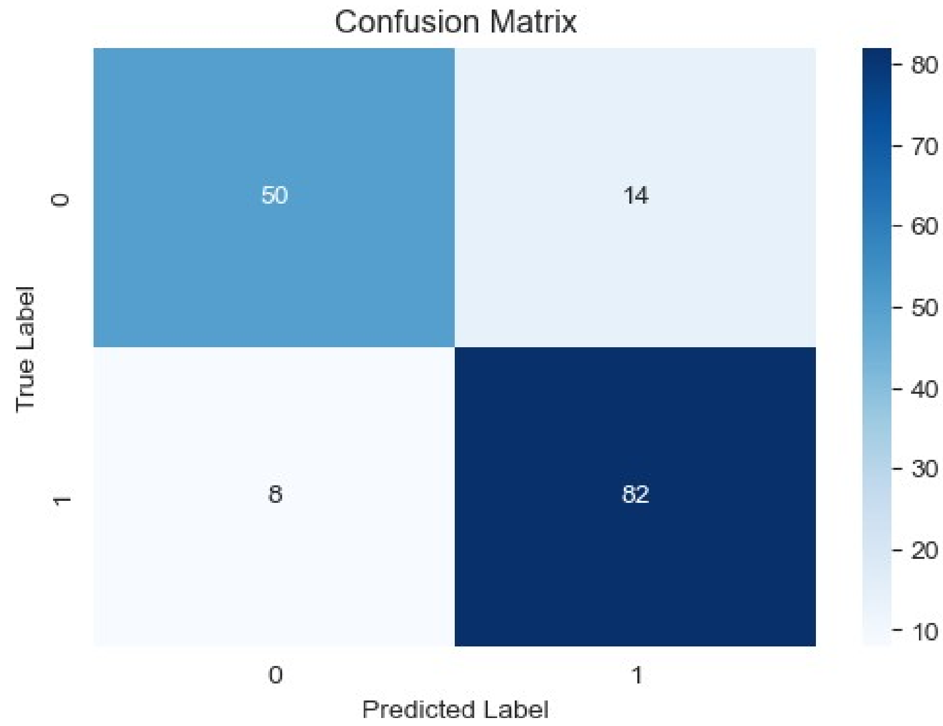
1.Model Training and evaluation:

```
from sklearn.model_selection import train_test_split
from sklearn.linear_model import LogisticRegression
from sklearn.metrics import classification_report, accuracy_score
from sklearn.preprocessing import StandardScaler

# Step 1: Select features and target
features = ['ca_log', 'thal', 'oldpeak', 'thalach', 'exang', 'cp',
'sex', 'slope']
X = df_clean[features]
y = df_clean['target']

# Step 2: Normalize features
scaler = StandardScaler()
X_scaled = scaler.fit_transform(X)

# Step 3: Split dataset into train and test sets (80% train, 20% test)
X_train, X_test, y_train, y_test = train_test_split(X_scaled, y,
test_size=0.2, random_state=42)

# Step 4: Build Logistic Regression model
model = LogisticRegression(random_state=42)
model.fit(X_train, y_train)

# Step 5: Predict on test set
y_pred = model.predict(X_test)

# Step 6: Evaluate the model
print("Accuracy:", accuracy_score(y_test, y_pred))
print("\nClassification Report:\n", classification_report(y_test,
y_pred))

y_train_pred = model.predict(X_train)
train_accuracy = accuracy_score(y_train, y_train_pred)

print("Train Accuracy:", train_accuracy)
```

```
Accuracy: 0.8571428571428571

Classification Report:
               precision    recall  f1-score   support

         0.0       0.86      0.78      0.82        64
         1.0       0.85      0.91      0.88        90

    accuracy                           0.86       154
   macro avg       0.86      0.85      0.85       154
weighted avg       0.86      0.86      0.86       154

Train Accuracy: 0.8666666666666667
```

```
import seaborn as sns
import matplotlib.pyplot as plt
from sklearn.metrics import confusion_matrix
```

```python
# Compute the confusion matrix
cm = confusion_matrix(y_test, y_pred)

# Plot the confusion matrix as a heatmap
plt.figure(figsize=(6, 4))
sns.heatmap(cm, annot=True, fmt='d', cmap='Blues', xticklabels=[0, 1],
yticklabels=[0, 1])
plt.xlabel('Predicted Label')  # Label for x-axis
plt.ylabel('True Label')       # Label for y-axis
plt.title('Confusion Matrix')  # Title of the plot
plt.show()
```



Milestone 4: Deployment

```python
import joblib

# Save the trained model
joblib.dump(model, 'heart_disease_model.pkl')
```

```
['heart_disease_model.pkl']
```

```python
import streamlit
```

```
!streamlit run app.py
```