Step 1: Data Collection & Understanding

In [18]:

```
# Importing pandas for data handling
import pandas as pd
# Pandas makes data cleaning and analysis faster and easier
# pandas can handle large datasets efficiently
class DataLoader:
    """
    This class is responsible for loading the dataset and providing an initial e

    Attributes:
        file_path (str): Path to the dataset file.
        df (DataFrame): Loaded dataset.
    """

    def __init__(self, file_path):
        """
        Initializes the DataLoader with the path to the dataset.

        Parameters:
            file_path (str): Path to the CSV dataset file.
        """
        self.file_path = file_path
        self.df = None

    def load_data(self):
        """
        Loads the dataset from the provided file path and prints important initi

        Returns:
            DataFrame: The loaded dataset.
        """
        print("\nDataset Loading...")
        print("-" * 100)

        # Load the dataset
        self.df = pd.read_csv(self.file_path)

        # Print shape of the dataset (rows, columns)
        print("\nDataset Loaded Successfully!")
        print("➞ Shape of Dataset:", self.df.shape)
        print("-" * 100)

        # Print the data types of each column
        print(" Data Types:\n")
        print(self.df.dtypes)
        print("-" * 100)

        # Display first 5 rows of the dataset
        print("First 5 Rows:\n")
        print(self.df.head())
        print("-" * 100)

        # Display missing values in the dataset
        print("Missing Values (Column-wise):\n")
        print(self.df.isnull().sum())
        print("-" * 100)

        # Show statistical summary of numeric features
        print("Statistical Summary (Numerical Columns):\n")
        print(self.df.describe().T)
        print("-" * 100)

        return self.df


loader = DataLoader("heart.csv")
df = loader.load_data()
```

```
Dataset Loading...
---------------------------------------------------------------------------------
-------------------

Dataset Loaded Successfully!
➞ Shape of Dataset: (918, 12)
---------------------------------------------------------------------------------
-------------------
 Data Types:

Age                 int64
Sex                object
ChestPainType      object
RestingBP           int64
Cholesterol         int64
FastingBS           int64
RestingECG         object
MaxHR               int64
ExerciseAngina     object
Oldpeak           float64
ST_Slope           object
HeartDisease        int64
dtype: object
---------------------------------------------------------------------------------
-------------------
First 5 Rows:

   Age Sex ChestPainType  RestingBP  Cholesterol  FastingBS RestingECG  MaxHR  \
0   40   M           ATA        140          289          0     Normal    172
1   49   F           NAP        160          180          0     Normal    156
2   37   M           ATA        130          283          0         ST     98
3   48   F           ASY        138          214          0     Normal    108
4   54   M           NAP        150          195          0     Normal    122

  ExerciseAngina  Oldpeak ST_Slope  HeartDisease
0              N      0.0       Up             0
1              N      1.0     Flat             1
2              N      0.0       Up             0
3              Y      1.5     Flat             1
4              N      0.0       Up             0
---------------------------------------------------------------------------------
-------------------
Missing Values (Column-wise):

Age               0
Sex               0
ChestPainType     0
RestingBP         0
Cholesterol       0
FastingBS         0
RestingECG        0
MaxHR             0
ExerciseAngina    0
Oldpeak           0
ST_Slope          0
HeartDisease      0
dtype: int64
---------------------------------------------------------------------------------
-------------------
Statistical Summary (Numerical Columns):
```

```
              count        mean         std   min     25%    50%    75%    max
Age           918.0   53.510893    9.432617  28.0   47.00   54.0   60.0   77.0
RestingBP     918.0  132.396514   18.514154   0.0  120.00  130.0  140.0  200.0
Cholesterol   918.0  198.799564  109.384145   0.0  173.25  223.0  267.0  603.0
FastingBS     918.0    0.233115    0.423046   0.0    0.00    0.0    0.0    1.0
MaxHR         918.0  136.809368   25.460334  60.0  120.00  138.0  156.0  202.0
Oldpeak       918.0    0.887364    1.066570  -2.6    0.00    0.6    1.5    6.2
HeartDisease  918.0    0.553377    0.497414   0.0    0.00    1.0    1.0    1.0
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-------------------
```

Step 2: Preprocessing, Univariate & Bivariate Analysis

In [19]:

```
import seaborn as sns # Built on top of matplotlib, seaborn makes it easy to cre
import matplotlib.pyplot as plt # Low-level plotting library for creating visual
import numpy as np      # Provides numerical operations and supports fast array
from sklearn.preprocessing import StandardScaler # From Scikit-learn, this class
# Crucial for machine learning algorithms that rely on feature scaling.

class DataPreprocessor:
    """
    This class handles preprocessing, univariate analysis, and bivariate analysi
    """

    def __init__(self, df):
        self.df = df

    def preprocess(self):
        """
        Handles missing values, encodes categorical variables, and returns the p
        """
        print("Starting Data Preprocessing...")
        print("-" * 100)

        # Handling missing values (if any)
        if self.df.isnull().sum().sum() > 0:
            self.df = self.df.fillna(self.df.median(numeric_only=True))
            print("Missing values filled with median of respective columns.")

        # Encoding categorical features
        self.df = pd.get_dummies(self.df, drop_first=True)
        print("Categorical Variables Encoded.")
        print("-" * 100)

        print("Data Preprocessing Completed Successfully.")
        print("-" * 100)
        return self.df

    def univariate_analysis(self):
        """
        Performs univariate analysis including countplots, pie charts, and histo
        """
        print("Univariate Analysis Started...")
        print("-" * 100)
        # Countplot of Target Variable
        sns.countplot(x='HeartDisease', data=self.df)
        plt.title("Target Class Distribution (Countplot)")
        plt.show()

        # Pie Chart of Target Variable
        target_counts = self.df['HeartDisease'].value_counts()
        plt.figure(figsize=(6, 6))
        plt.pie(target_counts, labels=['No Heart Disease', 'Heart Disease'], aut
        plt.title("Target Class Distribution (Pie Chart)")
        plt.show()

        # Histograms of Numerical Features
        numeric_cols = self.df.select_dtypes(include=[np.number]).columns.drop('
        self.df[numeric_cols].hist(bins=20, figsize=(14, 10), edgecolor='black')
        plt.suptitle("Histogram of Numerical Features", fontsize=16)
        plt.show()

        print(self.df['HeartDisease'].value_counts())
        print("-" * 100)

    def bivariate_analysis(self):
        """
        Performs bivariate analysis including correlation heatmap and boxplots o
        """
        print("Bivariate Analysis Started...")
        print("-" * 100)

        # Correlation Heatmap
        plt.figure(figsize=(12, 8))
        sns.heatmap(self.df.corr(), annot=True, cmap='coolwarm_r')
        plt.title("Correlation Heatmap")
        plt.show()

        # Boxplots for Numerical Features vs Target
        numeric_cols = self.df.select_dtypes(include=[np.number]).columns.drop('
        for col in numeric_cols:
            plt.figure(figsize=(8, 5))
            sns.boxplot(x='HeartDisease', y=col, data=self.df)
            plt.title(f"{col} vs HeartDisease (Boxplot)")
            plt.show()

        # Optional Pairplot for smaller datasets (commented out)
        # sns.pairplot(self.df, hue='HeartDisease', diag_kind='hist')
        # plt.show()

        print("-" * 100)



preprocessor = DataPreprocessor(df)
df = preprocessor.preprocess()
preprocessor.univariate_analysis()
preprocessor.bivariate_analysis()
```

```
Starting Data Preprocessing...
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Categorical Variables Encoded.
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Data Preprocessing Completed Successfully.
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-------------------
Univariate Analysis Started...
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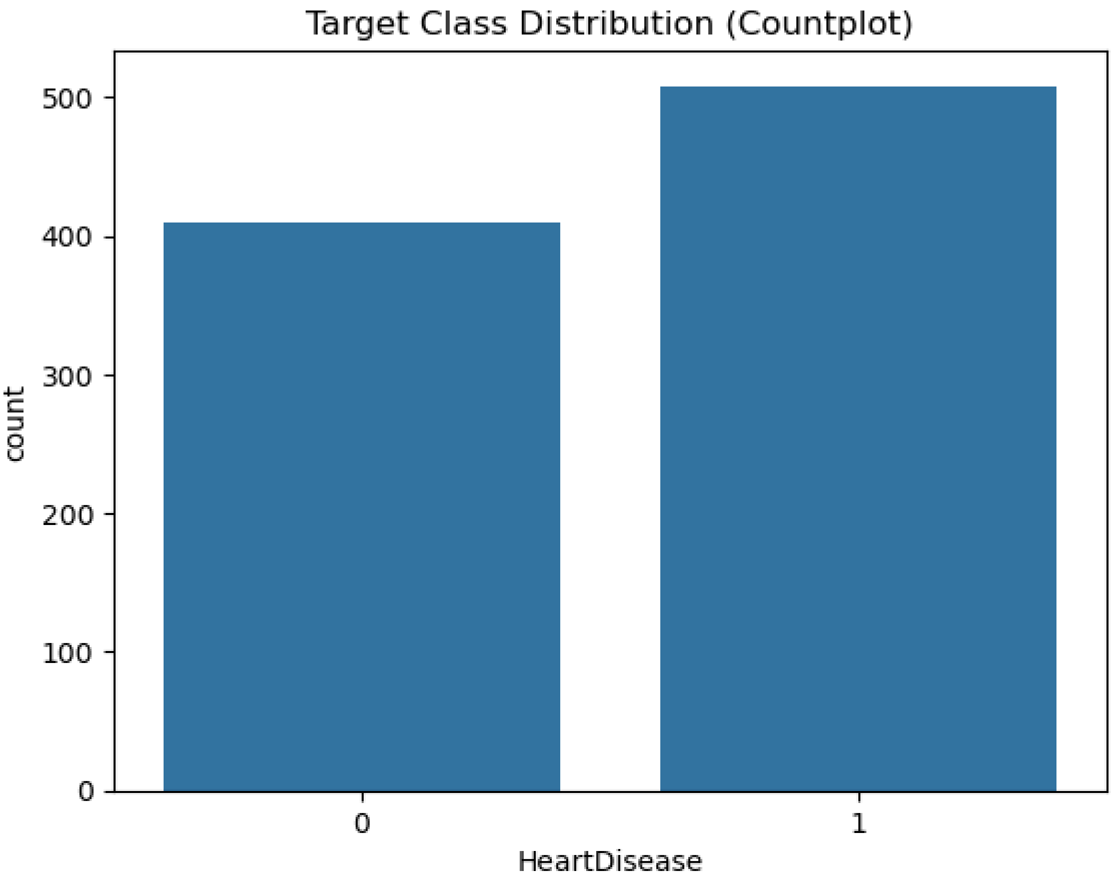
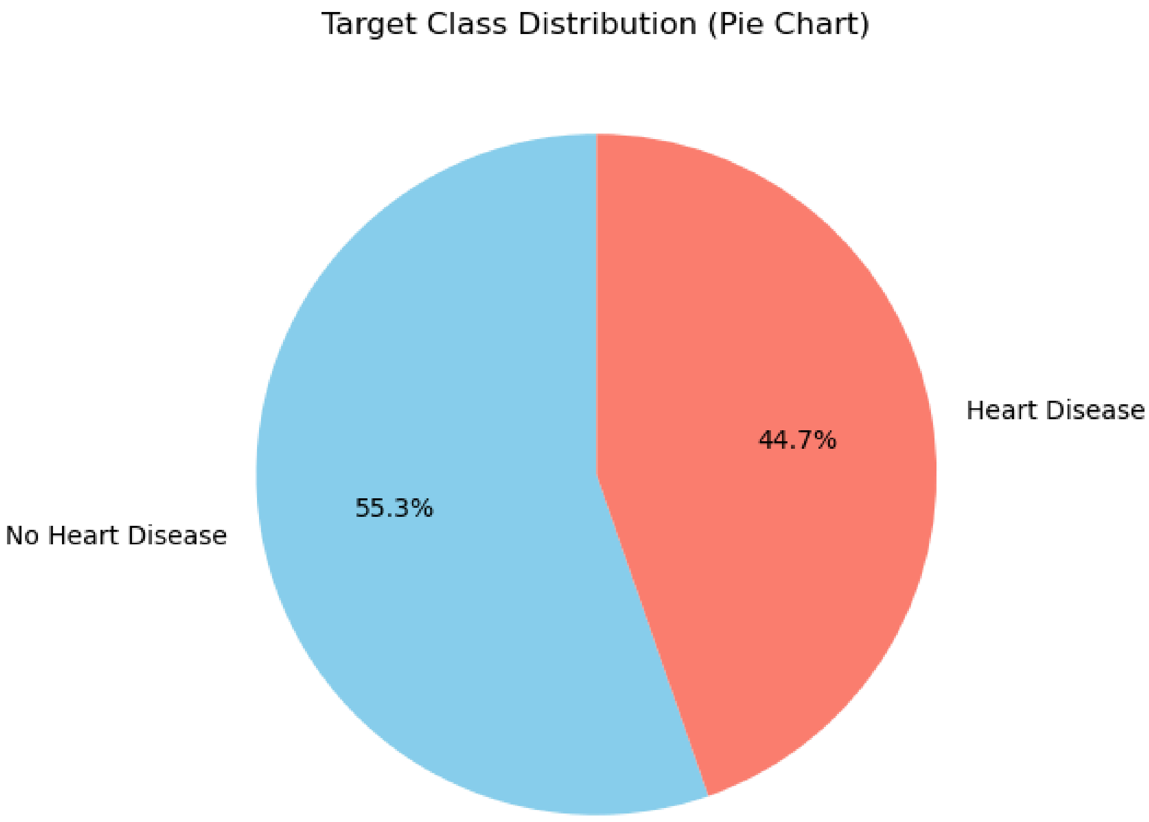
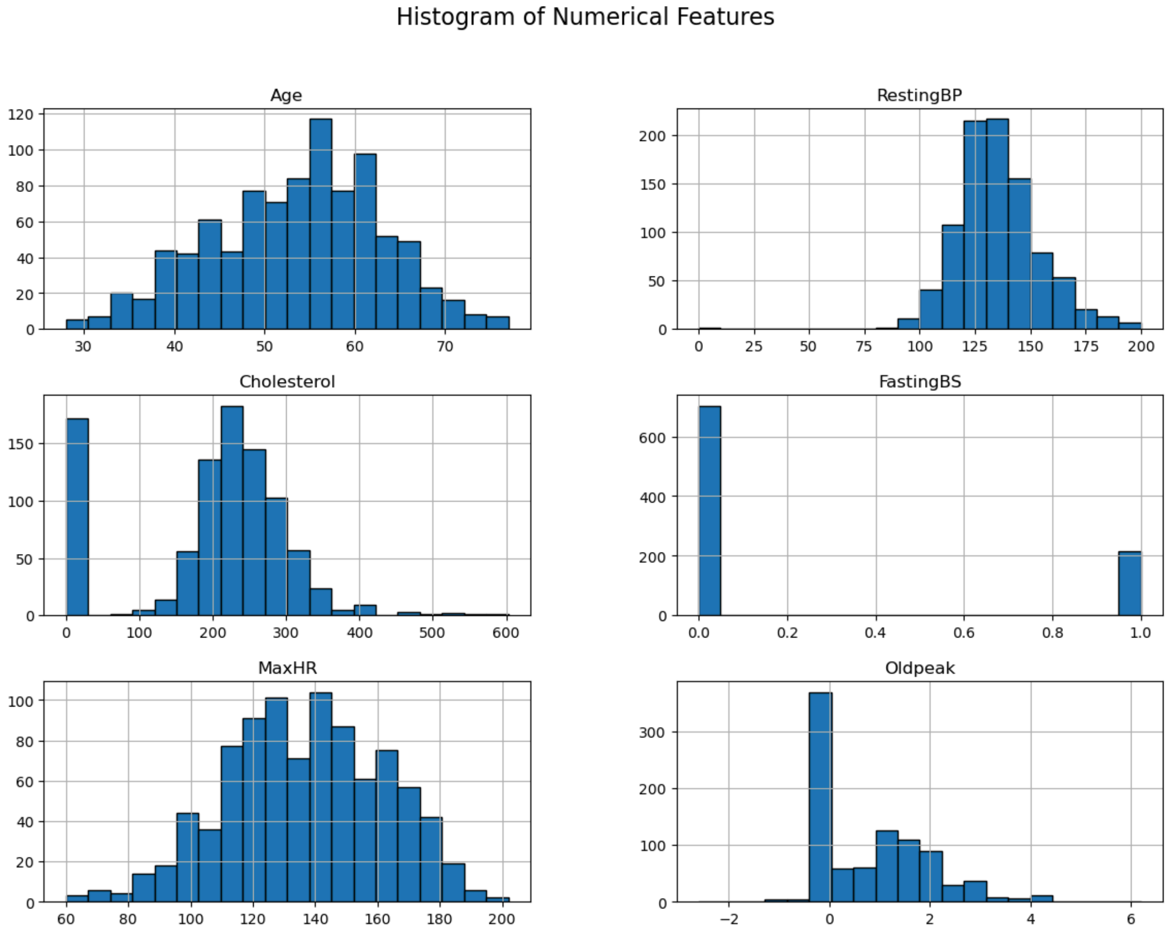
```




Target Class Distribution (Pie Chart)
Heart Disease
44.7%
55.3%
No Heart Disease


Histogram of Numerical Features
Age
0
20
40
60
80
100
120
30
40
50
60
70
RestingBP
0
50
100
150
200
0
25
50
75
100
125
150
175
200
Cholesterol
0
50
100
150
0
100
200
300
400
500
600
FastingBS
0
200
400
600
0.0
0.2
0.4
0.6
0.8
1.0
MaxHR
0
20
40
60
80
100
60
80
100
120
140
160
180
200
Oldpeak
0
100
200
300
−2
0
2
4
6

```
HeartDisease
1    508
0    410
Name: count, dtype: int64
--------------------------------------------------------------------------------
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Bivariate Analysis Started...
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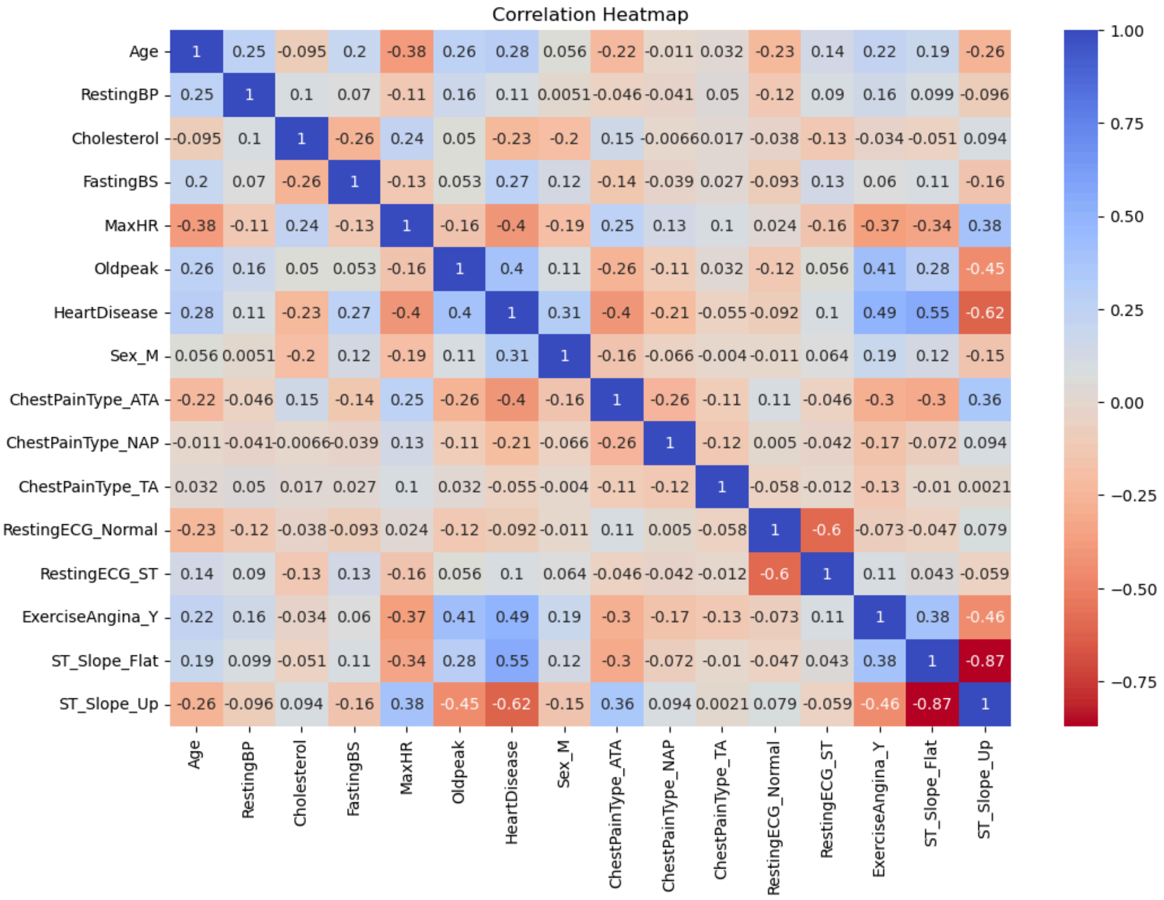
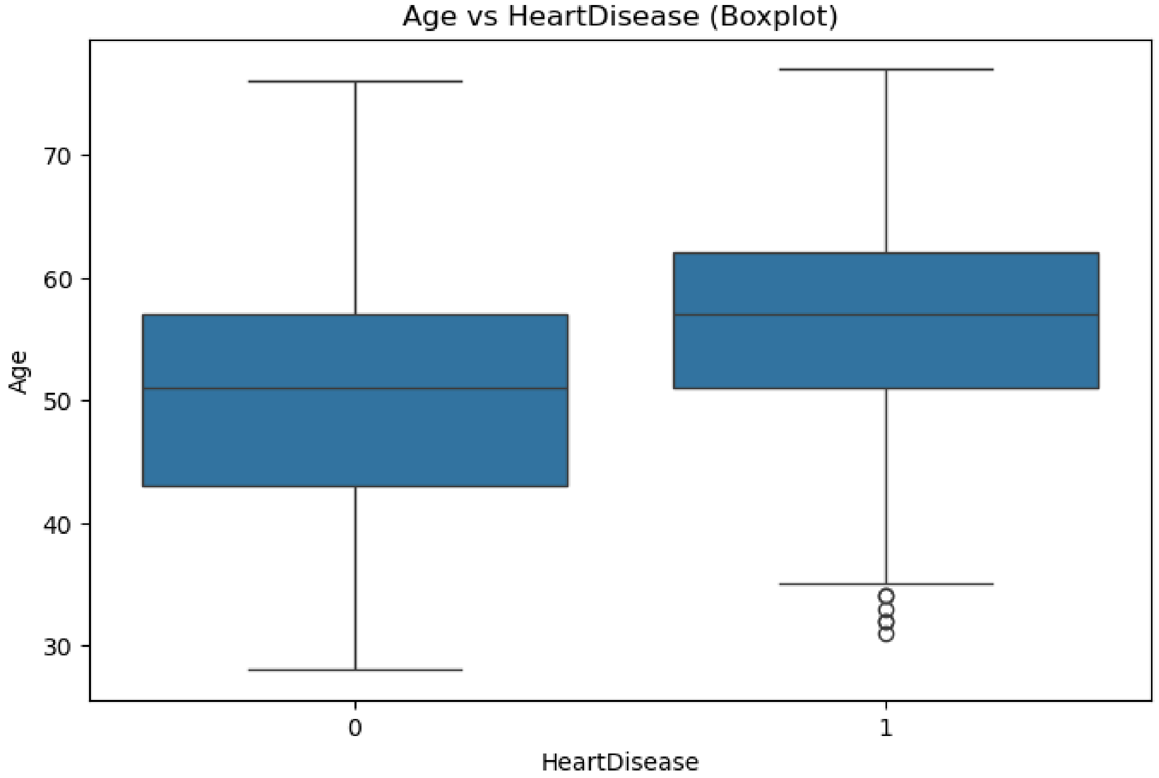
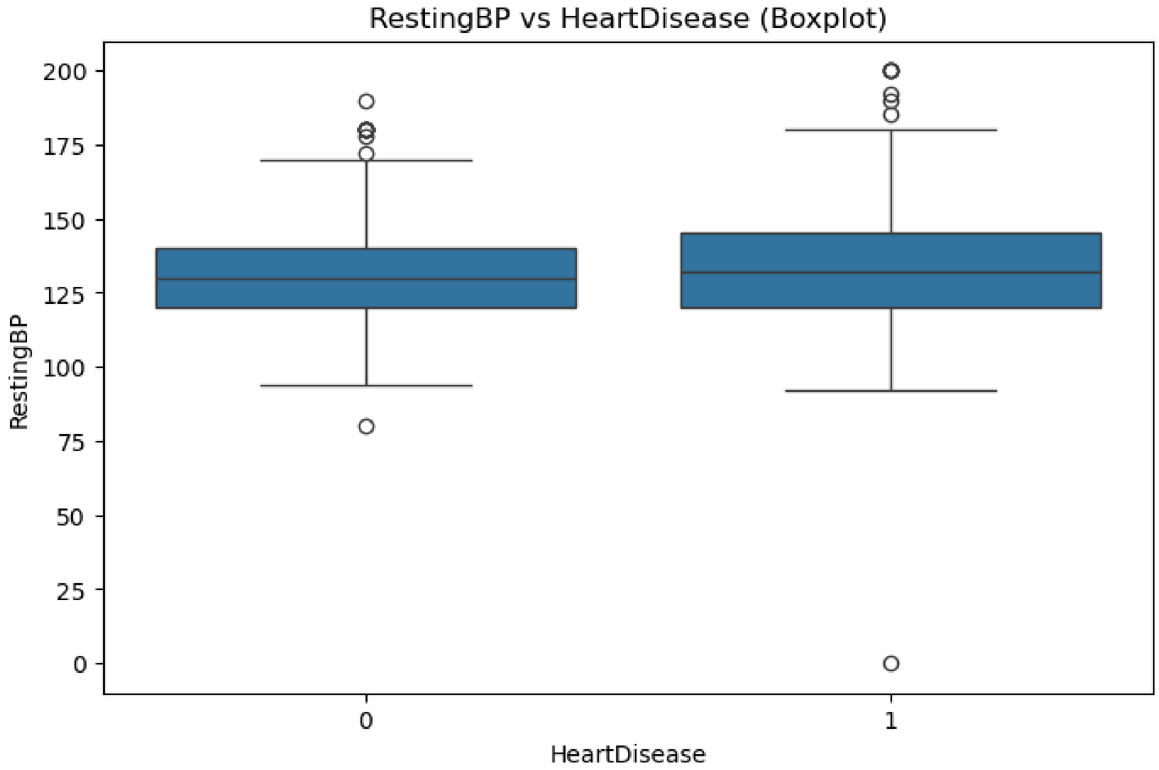
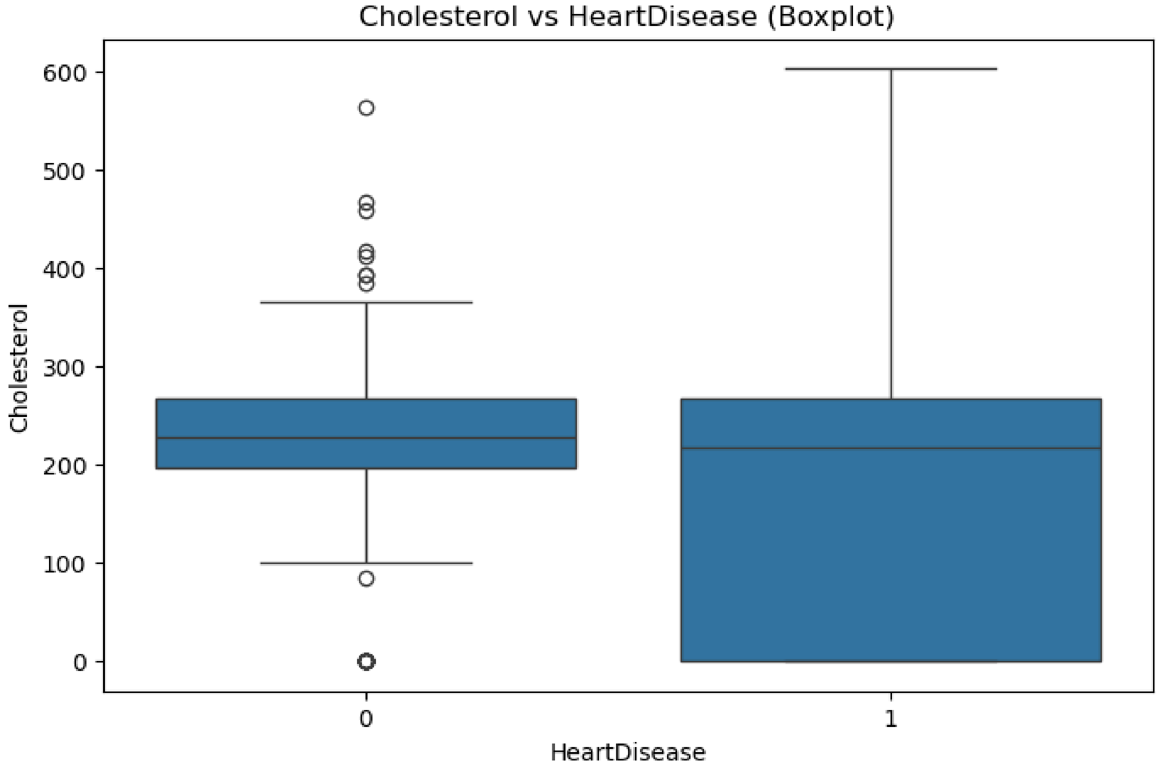
```

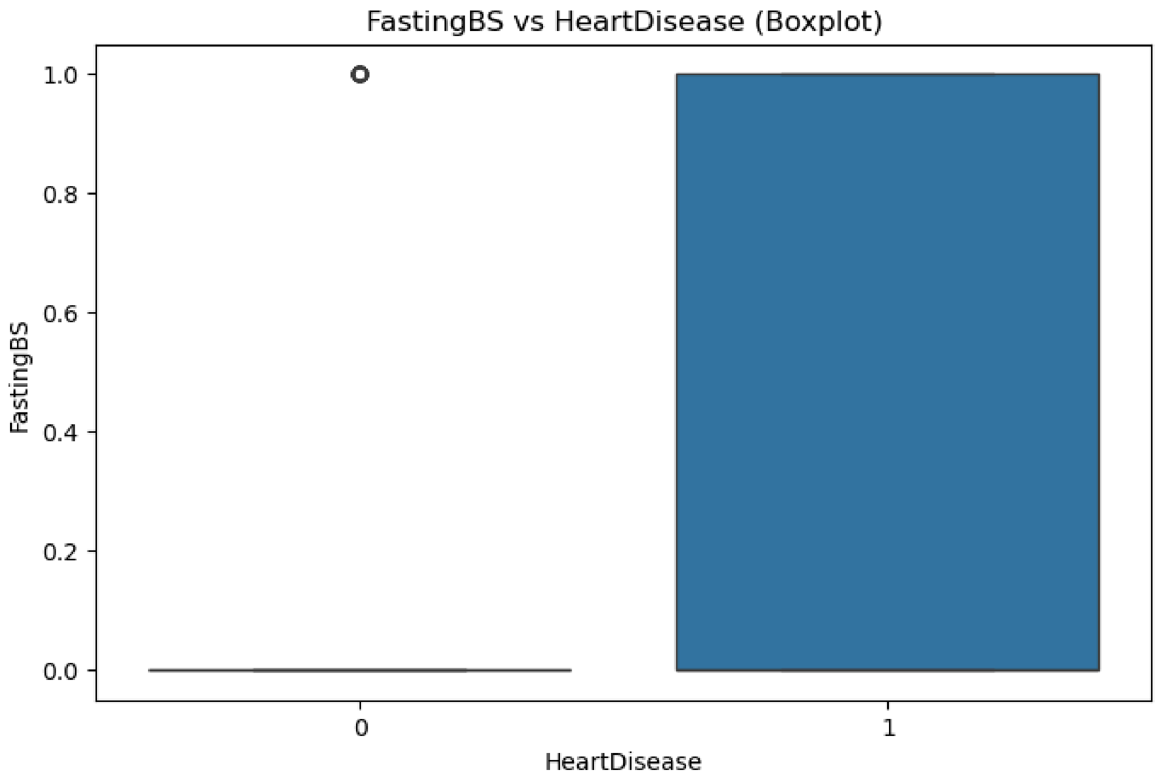

Correlation Heatmap

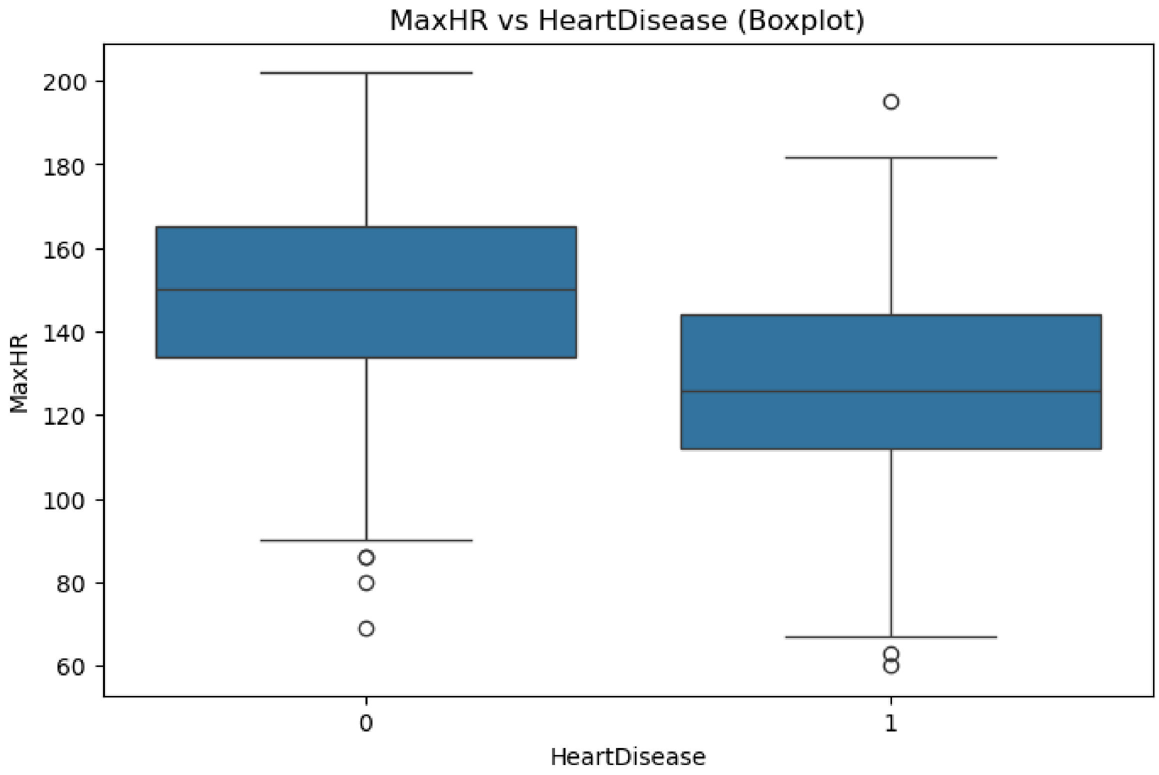
	Age	RestingBP	Cholesterol	FastingBS	MaxHR	Oldpeak	HeartDisease	Sex_M	ChestPainType_ATA	ChestPainType_NAP	ChestPainType_TA	RestingECG_Normal	RestingECG_ST	ExerciseAngina_Y	ST_Slope_Flat	ST_Slope_Up
Age	1	0.25	-0.095	0.2	-0.38	0.26	0.28	0.056	-0.22	-0.011	0.032	-0.23	0.14	0.22	0.19	-0.26
RestingBP	0.25	1	0.1	0.07	-0.11	0.16	0.11	0.0051	-0.046	-0.041	0.05	-0.12	0.09	0.16	0.099	-0.096
Cholesterol	-0.095	0.1	1	-0.26	0.24	0.05	-0.23	-0.2	0.15	-0.0066	0.017	-0.038	-0.13	-0.034	-0.051	0.094
FastingBS	0.2	0.07	-0.26	1	-0.13	0.053	0.27	0.12	-0.14	-0.039	0.027	-0.093	0.13	0.06	0.11	-0.16
MaxHR	-0.38	-0.11	0.24	-0.13	1	-0.16	-0.4	-0.19	0.25	0.13	0.1	0.024	-0.16	-0.37	-0.34	0.38
Oldpeak	0.26	0.16	0.05	0.053	-0.16	1	0.4	0.11	-0.26	-0.11	0.032	-0.12	0.056	0.41	0.28	-0.45
HeartDisease	0.28	0.11	-0.23	0.27	-0.4	0.4	1	0.31	-0.4	-0.21	-0.055	-0.092	0.1	0.49	0.55	-0.62
Sex_M	0.056	0.0051	-0.2	0.12	-0.19	0.11	0.31	1	-0.16	-0.066	-0.004	-0.011	0.064	0.19	0.12	-0.15
ChestPainType_ATA	-0.22	-0.046	0.15	-0.14	0.25	-0.26	-0.4	-0.16	1	-0.26	-0.11	0.11	-0.046	-0.3	-0.3	0.36
ChestPainType_NAP	-0.011	-0.041	-0.0066	-0.039	0.13	-0.11	-0.21	-0.066	-0.26	1	-0.12	0.005	-0.042	-0.17	-0.072	0.094
ChestPainType_TA	0.032	0.05	0.017	0.027	0.1	0.032	-0.055	-0.004	-0.11	-0.12	1	-0.058	-0.012	-0.13	-0.01	0.0021
RestingECG_Normal	-0.23	-0.12	-0.038	-0.093	0.024	-0.12	-0.092	-0.011	0.11	0.005	-0.058	1	-0.6	-0.073	-0.047	0.079
RestingECG_ST	0.14	0.09	-0.13	0.13	-0.16	0.056	0.1	0.064	-0.046	-0.042	-0.012	-0.6	1	0.11	0.043	-0.059
ExerciseAngina_Y	0.22	0.16	-0.034	0.06	-0.37	0.41	0.49	0.19	-0.3	-0.17	-0.13	-0.073	0.11	1	0.38	-0.46
ST_Slope_Flat	0.19	0.099	-0.051	0.11	-0.34	0.28	0.55	0.12	-0.3	-0.072	-0.01	-0.047	0.043	0.38	1	-0.87
ST_Slope_Up	-0.26	-0.096	0.094	-0.16	0.38	-0.45	-0.62	-0.15	0.36	0.094	0.0021	0.079	-0.059	-0.46	-0.87	1

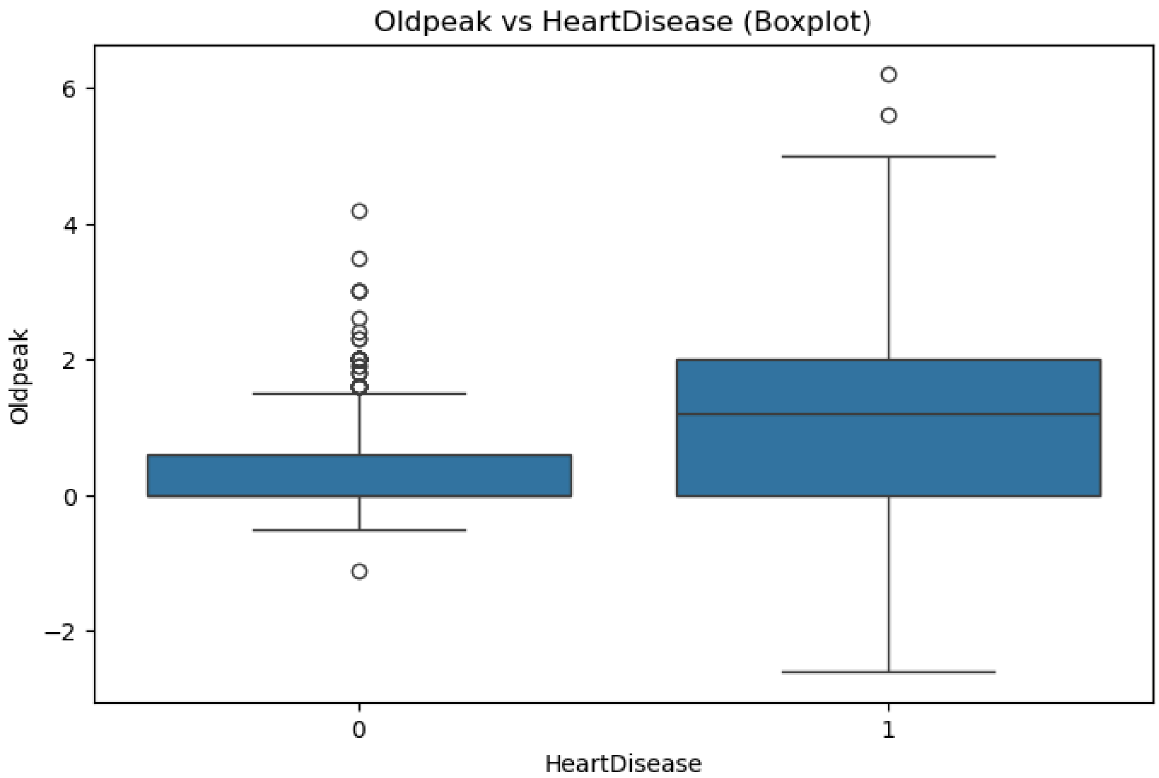

Age vs HeartDisease (Boxplot)


RestingBP vs HeartDisease (Boxplot)
RestingBP
200
175
150
125
100
75
50
25
0
0
1
HeartDisease


Cholesterol vs HeartDisease (Boxplot)
Cholesterol
600
500
400
300
200
100
0
0
1
HeartDisease


FastingBS vs HeartDisease (Boxplot)
FastingBS
1.0
0.8
0.6
0.4
0.2
0.0
0
1
HeartDisease


MaxHR vs HeartDisease (Boxplot)
MaxHR
200
180
160
140
120
100
80
60
0
1
HeartDisease



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```

Step 3: Data Splitting

In [20]:

```python
from sklearn.model_selection import train_test_split # Splits your dataset into
from sklearn.preprocessing import StandardScaler # Standardizes/Scales your nume

class DataSplitter:
    """
    Splits the dataset into training and testing sets and applies feature scalin
    """

    def __init__(self, df):
        self.df = df

    def split(self):
        # Step 1: Separate Features and Target Variable
        X = self.df.drop('HeartDisease', axis=1)
        y = self.df['HeartDisease']

        # Step 2: Train-Test Split (70% training, 30% testing)
        X_train, X_test, y_train, y_test = train_test_split(
            X, y, test_size=0.3, random_state=42
        )

        # Step 3: Apply Feature Scaling
        scaler = StandardScaler()
        X_train_scaled = scaler.fit_transform(X_train)
        X_test_scaled = scaler.transform(X_test)

        # Step 4: Display Shape of Data
        print("Data Split Completed:")
        print(f"Training Set Shape: {X_train.shape}")
        print(f"Testing Set Shape:  {X_test.shape}")
        print("Data Scaled Successfully.")
        print("-" * 100)

        return X_train_scaled, X_test_scaled, y_train, y_test, scaler

# Example Usage
splitter = DataSplitter(df)
X_train, X_test, y_train, y_test, scaler = splitter.split()
```

```
Data Split Completed:
Training Set Shape: (642, 15)
Testing Set Shape:  (276, 15)
Data Scaled Successfully.
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```