In [48]:
```
import pandas as pd
import seaborn as sns
import matplotlib.pyplot as plt
import numpy as np
from sklearn import preprocessing
from IPython.display import display, HTML

import warnings
warnings.filterwarnings("ignore")
```

In [49]:
```
df=pd.read_csv("D:/Final Project/archive (4)/2022/heart_data.csv")
display(HTML(df.head(10).to_html()))
```

	HeartDisease	BMI	Smoking	AlcoholDrinking	Stroke	PhysicalHealth	MentalHealth	DiffWalking
0	No	16.60	Yes	No	No	3.0	30.0	No
1	No	20.34	No	No	Yes	0.0	0.0	No
2	No	26.58	Yes	No	No	20.0	30.0	No
3	No	24.21	No	No	No	0.0	0.0	No
4	No	23.71	No	No	No	28.0	0.0	Yes
5	Yes	28.87	Yes	No	No	6.0	0.0	Yes
6	No	21.63	No	No	No	15.0	0.0	No
7	No	31.64	Yes	No	No	5.0	0.0	Yes
8	No	26.45	No	No	No	0.0	0.0	No
9	No	40.69	No	No	No	0.0	0.0	Yes

In [50]:
```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 319795 entries, 0 to 319794
Data columns (total 18 columns):
 #   Column            Non-Null Count   Dtype  
---  ------            --------------   -----  
 0   HeartDisease      319795 non-null  object 
 1   BMI               319795 non-null  float64
 2   Smoking           319795 non-null  object 
 3   AlcoholDrinking   319795 non-null  object 
 4   Stroke            319795 non-null  object 
 5   PhysicalHealth    319795 non-null  float64
 6   MentalHealth      319795 non-null  float64
 7   DiffWalking       319795 non-null  object 
 8   Sex               319795 non-null  object 
 9   AgeCategory       319795 non-null  object 
 10  Race              319795 non-null  object 
 11  Diabetic          319795 non-null  object 
 12  PhysicalActivity  319795 non-null  object 
 13  GenHealth         319795 non-null  object 
 14  SleepTime         319795 non-null  float64
 15  Asthma            319795 non-null  object 
 16  KidneyDisease     319795 non-null  object 
 17  SkinCancer        319795 non-null  object 
dtypes: float64(4), object(14)
memory usage: 43.9+ MB
```

In [51]:
```
duplicates = df[df.duplicated()]
duplicates
```

Out[51]:

	HeartDisease	BMI	Smoking	AlcoholDrinking	Stroke	PhysicalHealth	MentalHealth	DiffWa
2182	No	19.85	No	No	No	0.0	0.0	
3182	No	28.19	No	No	No	0.0	0.0	
3397	No	26.54	No	No	No	0.0	0.0	
3650	No	32.89	Yes	No	No	2.0	1.0	
4061	No	25.84	No	No	No	0.0	0.0	
...	...	...	...	...	...	...	...	
319671	No	25.06	No	No	No	0.0	0.0	
319689	No	27.44	No	No	No	0.0	0.0	
319726	No	30.41	No	No	No	0.0	0.0	
319751	No	34.96	No	No	No	0.0	0.0	
319776	No	27.98	No	No	No	0.0	0.0	

18078 rows × 18 columns

In [52]:
```
df.drop_duplicates(inplace=True)
df
```

Out[52]:

	HeartDisease	BMI	Smoking	AlcoholDrinking	Stroke	PhysicalHealth	MentalHealth	DiffW
0	No	16.60	Yes	No	No	3.0	30.0	
1	No	20.34	No	No	Yes	0.0	0.0	
2	No	26.58	Yes	No	No	20.0	30.0	
3	No	24.21	No	No	No	0.0	0.0	
4	No	23.71	No	No	No	28.0	0.0	
...	...	...	...	...	...	...	...	
319790	Yes	27.41	Yes	No	No	7.0	0.0	
319791	No	29.84	Yes	No	No	0.0	0.0	
319792	No	24.24	No	No	No	0.0	0.0	
319793	No	32.81	No	No	No	0.0	0.0	
319794	No	46.56	No	No	No	0.0	0.0	

301717 rows × 18 columns

In [53]:

```
# Our Observation from the dataset
# Total Samle:  319795
# Total Duplicates : 18078
# The majority of features are categorical.
```

In [56]:

```
# Get unique values for the columns

unique_race = df['Race'].unique()
unique_general_health = df['GenHealth'].unique()
unique_diabetic = df['Diabetic'].unique()

print("Unique values in 'race' column:", unique_race)
print("Unique values in 'general health' column:", unique_general_health)
print("Unique values in 'diabetic' column:", unique_diabetic)
```

```
Unique values in 'race' column: ['3' '2' '1' '0' '5' '4']
Unique values in 'general health' column: ['3' '1' '2' '0' '4']
Unique values in 'diabetic' column: ['1' '0' '3' '4']
```

In [57]:

```
def categorize_bmi(BMI):
    if BMI <= 18.5:
        return 0
    elif 18.5 < BMI <= 25:
        return 1
    elif 25 < BMI <= 30:
        return 2
    elif BMI > 30:
        return 3

df['BMI'] = df['BMI'].apply(categorize_bmi)
```

In [58]:

```
df['AgeCategory']=df['AgeCategory'].replace('18-24','0')
df['AgeCategory']=df['AgeCategory'].replace('25-29','1')
```

```
df['AgeCategory']=df['AgeCategory'].replace('30-34','2')
df['AgeCategory']=df['AgeCategory'].replace('35-39','3')
df['AgeCategory']=df['AgeCategory'].replace('40-44','4')
df['AgeCategory']=df['AgeCategory'].replace('45-49','5')
df['AgeCategory']=df['AgeCategory'].replace('50-54','6')
df['AgeCategory']=df['AgeCategory'].replace('55-59','7')
df['AgeCategory']=df['AgeCategory'].replace('60-64','8')
df['AgeCategory']=df['AgeCategory'].replace('65-69','9')
df['AgeCategory']=df['AgeCategory'].replace('70-74','10')
df['AgeCategory']=df['AgeCategory'].replace('75-79','11')
df['AgeCategory']=df['AgeCategory'].replace('80 or older','12')
```

In [59]:

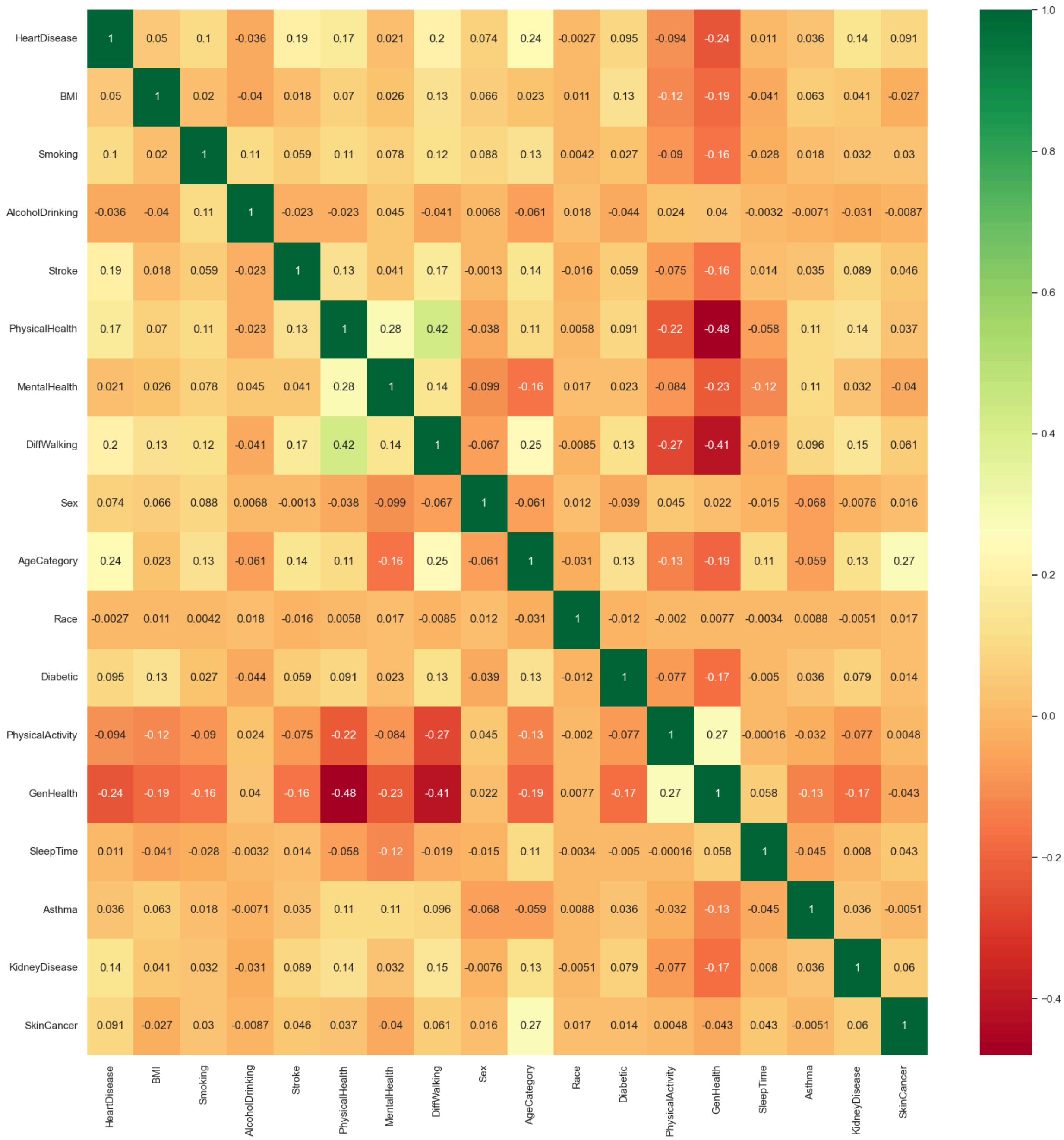
```
df['GenHealth']=df['GenHealth'].replace('Poor','0')
df['GenHealth']=df['GenHealth'].replace('Fair','1')
df['GenHealth']=df['GenHealth'].replace('Good','2')
df['GenHealth']=df['GenHealth'].replace('Very good','3')
df['GenHealth']=df['GenHealth'].replace('Excellent','4')

df['Race']=df['Race'].replace('American Indian/Alaskan Native','0')
df['Race']=df['Race'].replace('Asian','1')
df['Race']=df['Race'].replace('Black','2')
df['Race']=df['Race'].replace('White','3')
df['Race']=df['Race'].replace('Hispanic','4')
df['Race']=df['Race'].replace('Other','5')

df=df.replace('No','0')
df= df.replace('Yes','1')
df["Diabetic"]=df['Diabetic'].replace('No, borderline diabetes','3')
df["Diabetic"]=df['Diabetic'].replace('Yes (during pregnancy)','4')

df=df.replace('Female','0')
df= df.replace('Male','1')

display(HTML(df.head(10).to_html()))
```

	HeartDisease	BMI	Smoking	AlcoholDrinking	Stroke	PhysicalHealth	MentalHealth	DiffWalking
0	0	0	1	0	0	3.0	30.0	0
1	0	1	0	0	1	0.0	0.0	0
2	0	2	1	0	0	20.0	30.0	0
3	0	1	0	0	0	0.0	0.0	0
4	0	1	0	0	0	28.0	0.0	1
5	1	2	1	0	0	6.0	0.0	1
6	0	1	0	0	0	15.0	0.0	0
7	0	3	1	0	0	5.0	0.0	1
8	0	2	0	0	0	0.0	0.0	0
9	0	3	0	0	0	0.0	0.0	1

In [60]:

```
import seaborn as sns
#get correlations of each features in dataset
```

```
corrmat = df.corr()
top_corr_features = corrmat.index
plt.figure(figsize=(20,20))
#plot heat map
g=sns.heatmap(df[top_corr_features].corr(),annot=True,cmap="RdYlGn")
```



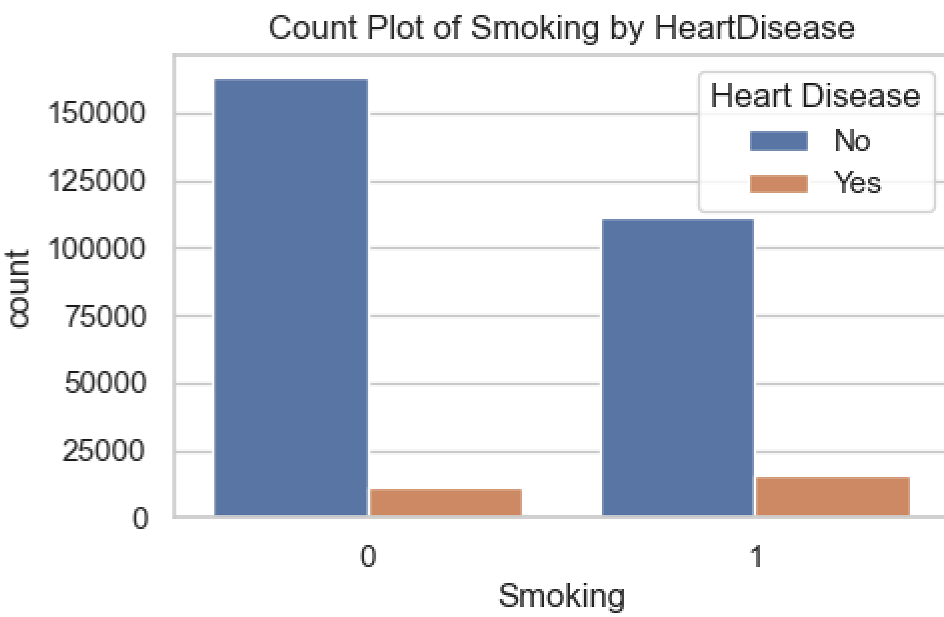
In [61]:
```
import seaborn as sns
import matplotlib.pyplot as plt

columns_to_plot = [
    'HeartDisease','Smoking', 'AlcoholDrinking', 'Stroke','DiffWalking', 'Sex', 'Diabe
    'KidneyDisease', 'SkinCancer']

sns.set_style('whitegrid')

plt.figure(figsize=(20, 24))
for i, column in enumerate(columns_to_plot, 1):
    # Find the order for the current column by sorting its unique values
```

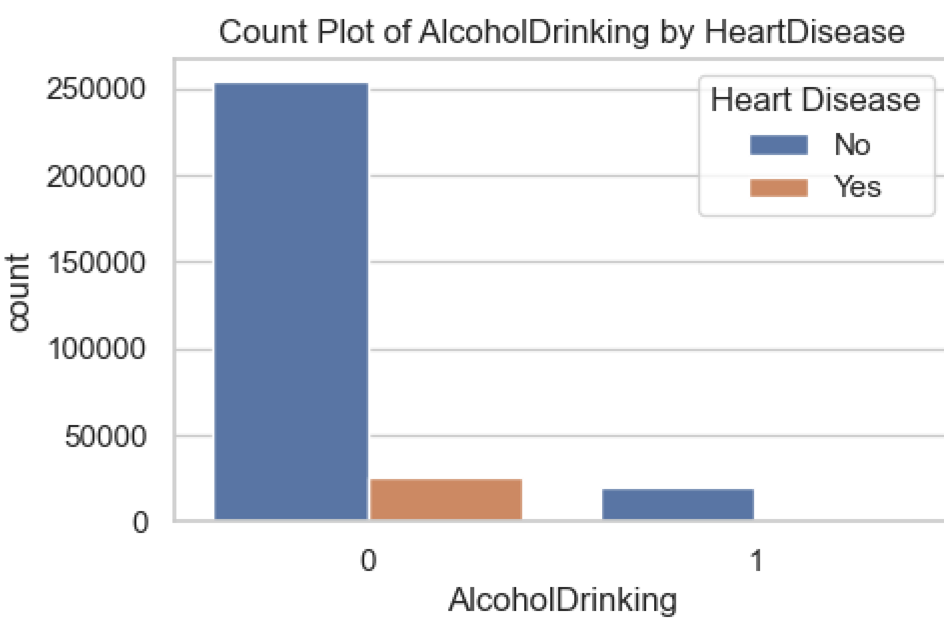
```
    order = sorted(df[column].unique())

    # Create the subplot
    plt.subplot(4, 3, i)

    # Generate the countplot with ordered X-axis
    sns.countplot(x=column, data=df, order=order, palette='RdBu_r')

    # Set the title and labels
    plt.title(f'Count Plot of {column}')
    plt.ylabel('Count')

# Adjust subplots layout
plt.tight_layout()
plt.show()
```

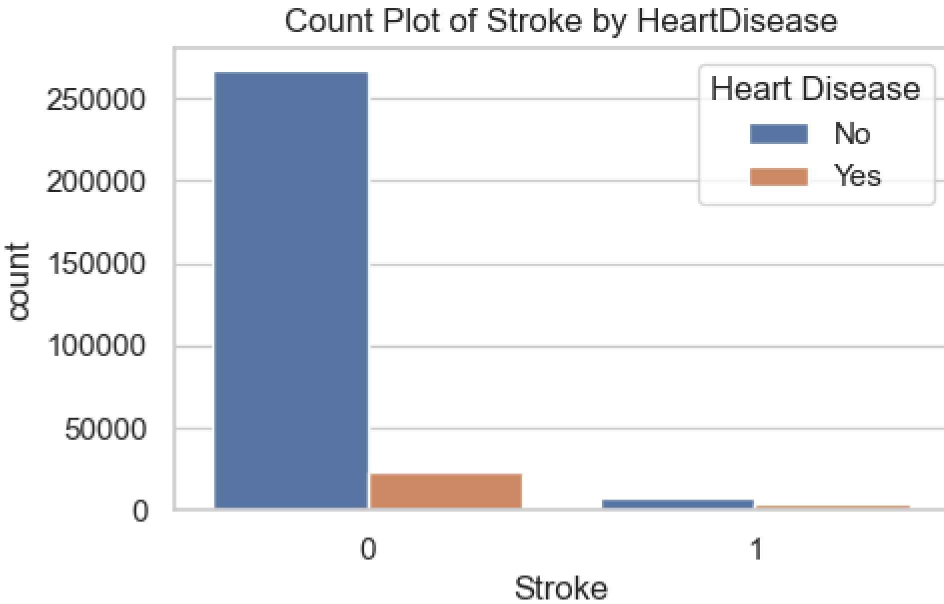
In [64]:

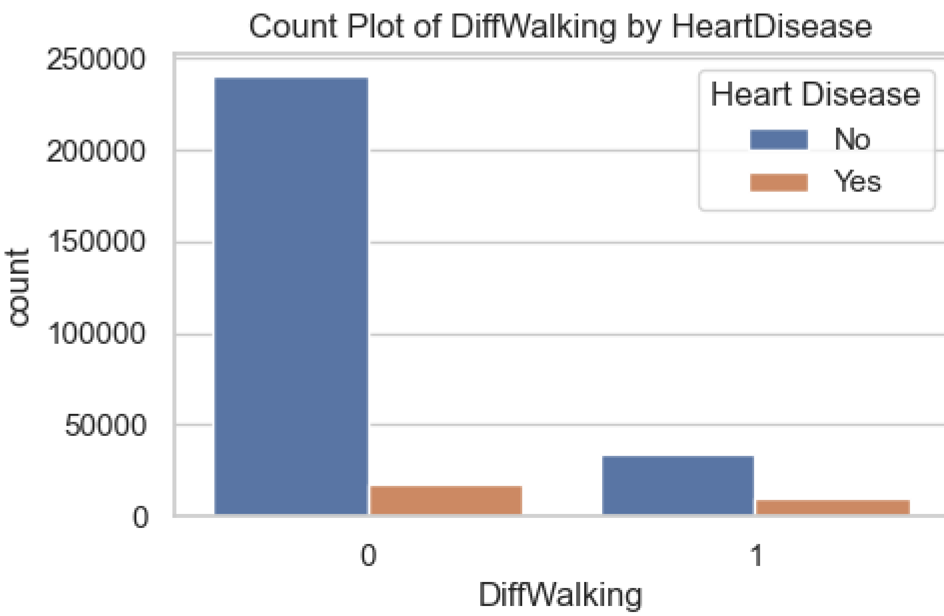
```
import seaborn as sns
import matplotlib.pyplot as plt
import pandas as pd

df['AgeCategory'] = pd.to_numeric(df['AgeCategory'])

# List of features to plot against 'HeartDisease'
features = ['Smoking', 'AlcoholDrinking', 'Stroke', 'DiffWalking', 'Sex',
            'Diabetic', 'PhysicalActivity', 'GenHealth', 'Asthma', 'KidneyDisease',
            'SkinCancer','AgeCategory', 'BMI']

# Setting the style
sns.set(style="whitegrid")
```

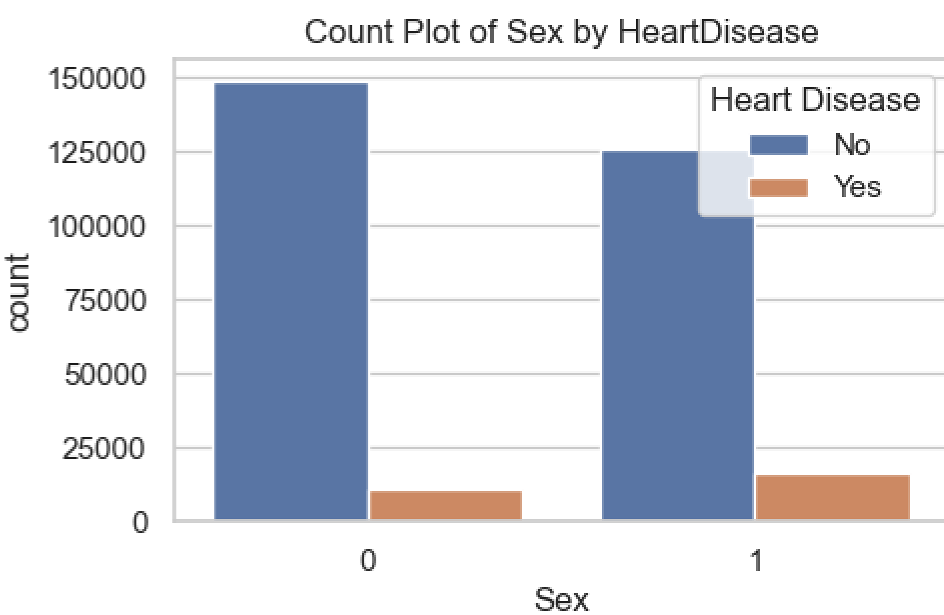
```
# Loop through the list of features
for feature in features:
    order = df[feature].value_counts().index.sort_values()
    plt.figure(figsize=(5, 3))
    sns.countplot(x=feature, data=df, hue='HeartDisease', order=order)
    plt.title(f'Count Plot of {feature} by HeartDisease')
    plt.legend(title='Heart Disease', labels=['No', 'Yes'])
    plt.show()
```

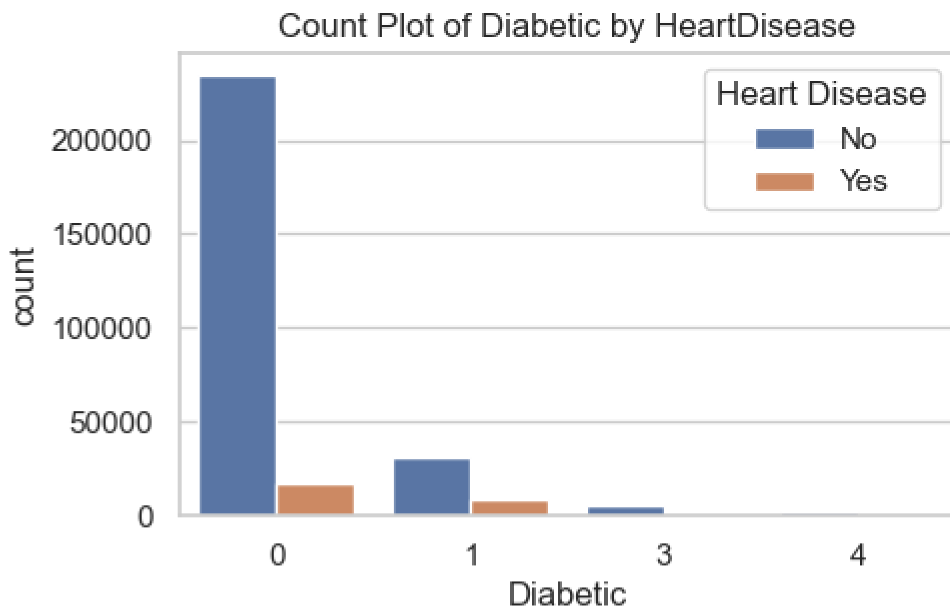


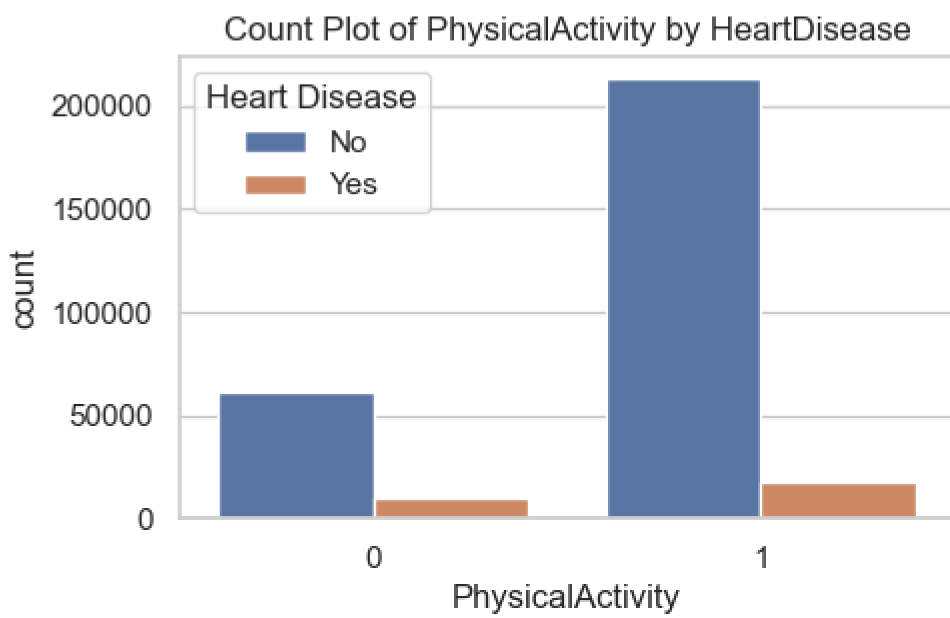


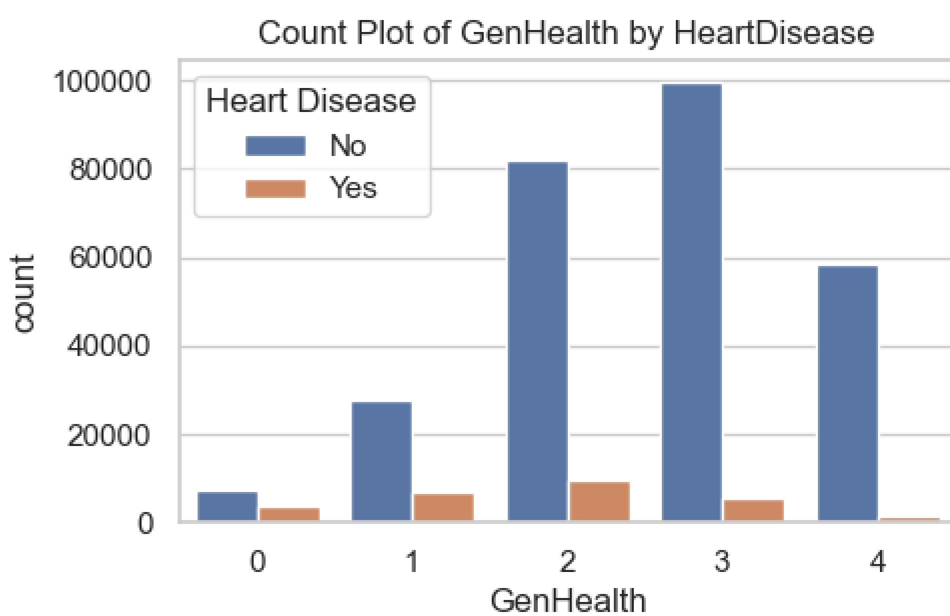

Count Plot of Stroke by HeartDisease
Heart Disease
No
Yes
count
250000
200000
150000
100000
50000
0
0
1
Stroke

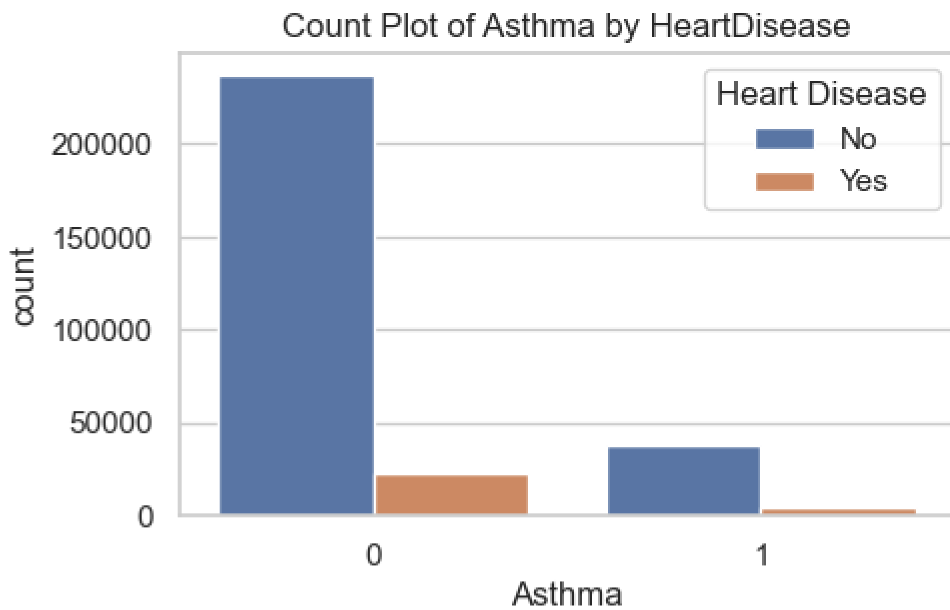

Count Plot of DiffWalking by HeartDisease
Heart Disease
No
Yes
count
250000
200000
150000
100000
50000
0
0
1
DiffWalking

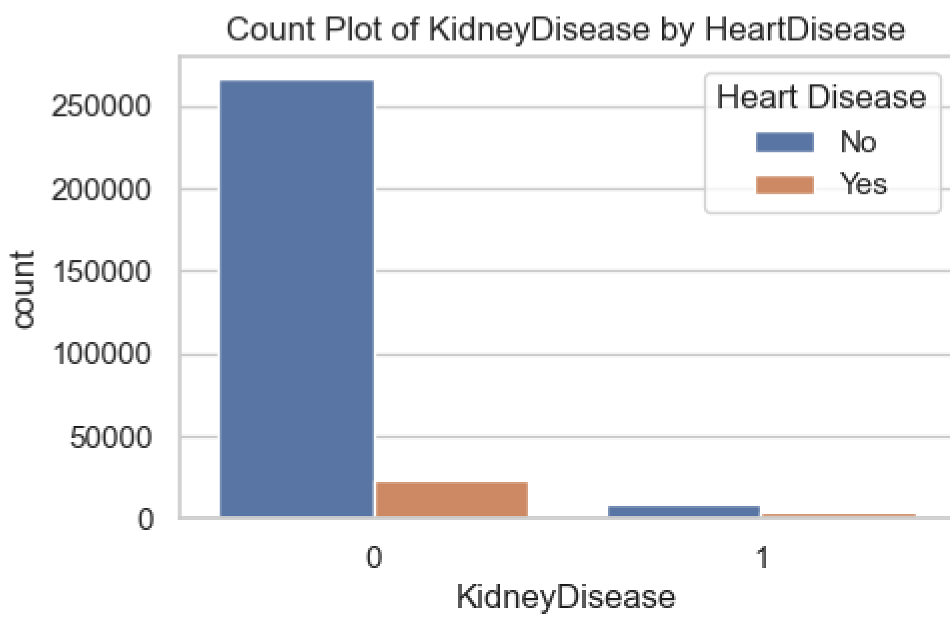

Count Plot of Sex by HeartDisease
Heart Disease
No
Yes
count
150000
125000
100000
75000
50000
25000
0
0
1
Sex

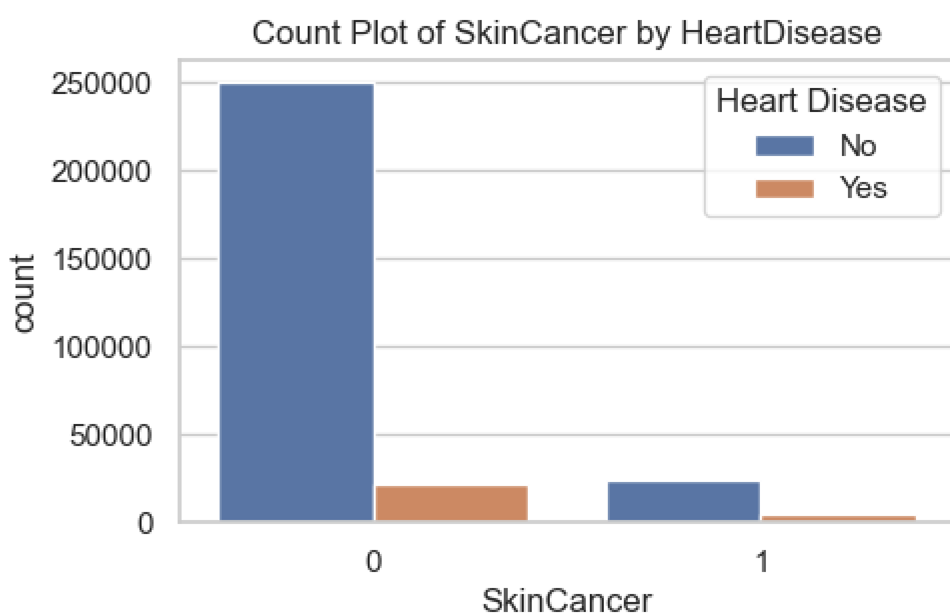

Count Plot of Diabetic by HeartDisease
Heart Disease
No
Yes
count
200000
150000
100000
50000
0
0
1
3
4
Diabetic

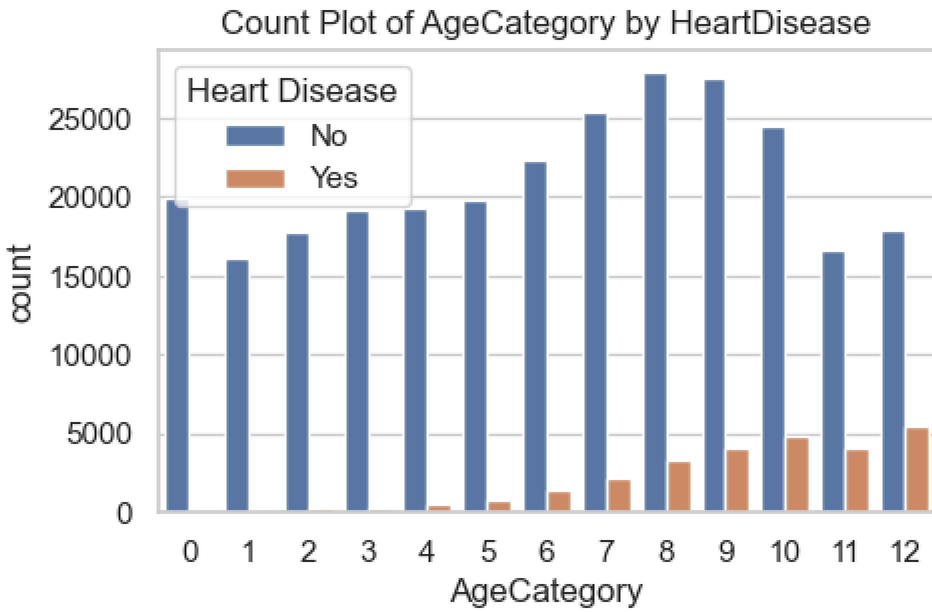

Count Plot of PhysicalActivity by HeartDisease
Heart Disease
No
Yes
count
200000
150000
100000
50000
0
0
1
PhysicalActivity

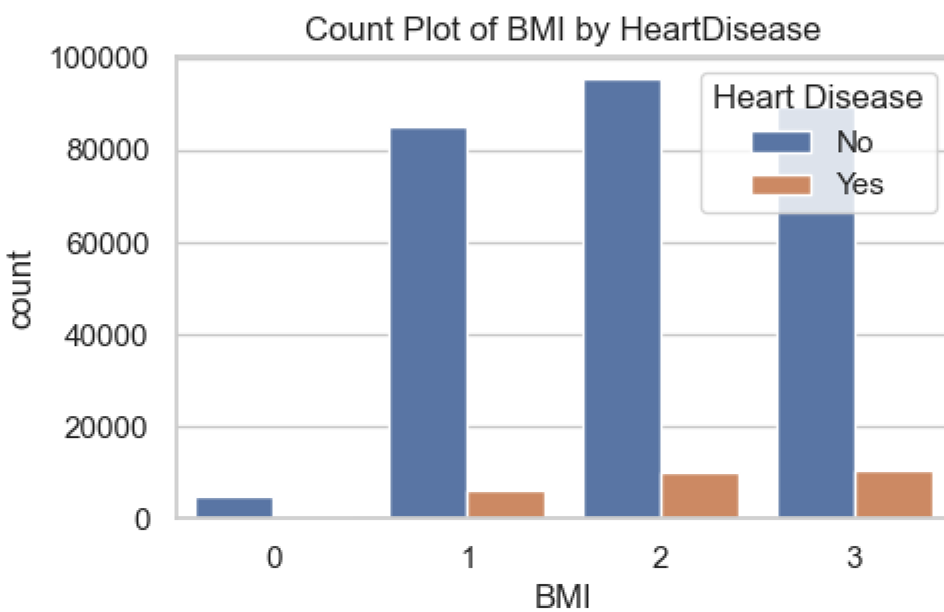

Count Plot of GenHealth by HeartDisease
Heart Disease
No
Yes
count
100000
80000
60000
40000
20000
0
0
1
2
3
4
GenHealth


Count Plot of Asthma by HeartDisease
Heart Disease
No
Yes
count
200000
150000
100000
50000
0
0
1
Asthma


Count Plot of KidneyDisease by HeartDisease
Heart Disease
No
Yes
count
250000
200000
150000
100000
50000
0
0
1
KidneyDisease


Count Plot of SkinCancer by HeartDisease
Heart Disease
No
Yes
count
250000
200000
150000
100000
50000
0
0
1
SkinCancer





In [13]:

```
# There is a severe class imbalance (heart disease vs healthy)
# Imbalanced attributes : HeartDisease, Alcohol drinking, Sroke, DiffWalking, Race, Di
```

In [14]:

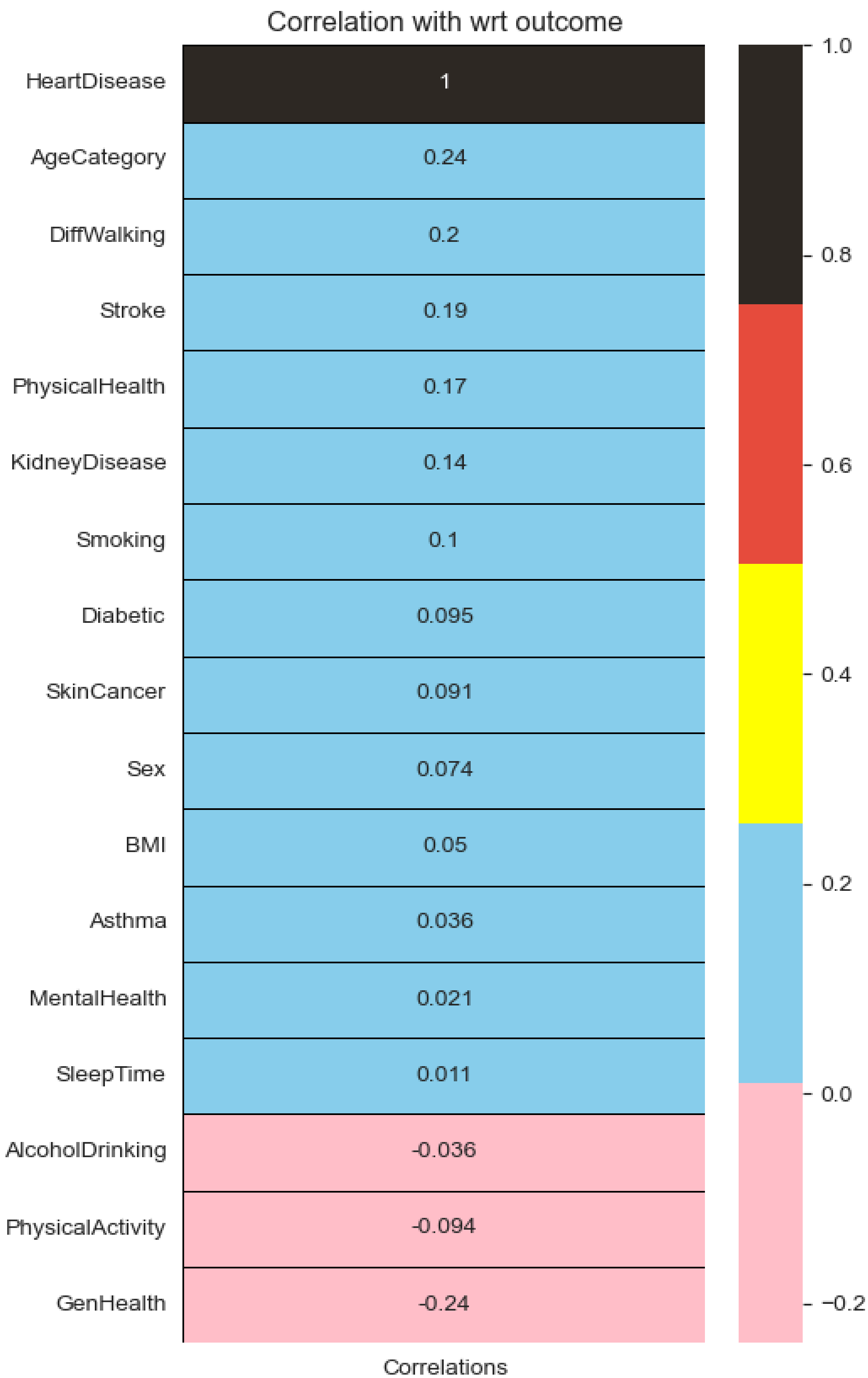
```
from sklearn.preprocessing import LabelEncoder
le = LabelEncoder()
df1 = df.copy(deep = True)


col = list(df.columns)
categorical_features = []
numerical_features = []
for i in df1.columns:
    if len(df[i].unique()) > 6:
        numerical_features.append(i)
    else:
        df1[i]=le.fit_transform(df1[i])
        categorical_features.append(i)
```

In [15]:
```
df_corr=df.drop("Race", axis=1)

df_corr['HeartDisease']=df_corr['HeartDisease'].astype(float)
df_corr['Smoking']=df_corr['Smoking'].astype(float)
df_corr['AlcoholDrinking']=df_corr['AlcoholDrinking'].astype(float)
df_corr['Stroke']=df_corr['Stroke'].astype(float)
df_corr['DiffWalking']=df_corr['DiffWalking'].astype(float)
df_corr['Sex']=df_corr['Sex'].astype(float)
df_corr['AgeCategory']=df_corr['AgeCategory'].astype(float)
df_corr['Diabetic']=df_corr['Diabetic'].astype(float)
df_corr['PhysicalActivity']=df_corr['PhysicalActivity'].astype(float)
df_corr['GenHealth']=df_corr['GenHealth'].astype(float)
df_corr['Asthma']=df_corr['Asthma'].astype(float)
df_corr['KidneyDisease']=df_corr['KidneyDisease'].astype(float)
df_corr['SkinCancer']=df_corr['SkinCancer'].astype(float)
```

In [16]:
```
df1.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Index: 301717 entries, 0 to 319794
Data columns (total 18 columns):
 #   Column            Non-Null Count   Dtype  
---  ------            --------------   -----  
 0   HeartDisease      301717 non-null  int32  
 1   BMI               301717 non-null  int64  
 2   Smoking           301717 non-null  int32  
 3   AlcoholDrinking   301717 non-null  int32  
 4   Stroke            301717 non-null  int32  
 5   PhysicalHealth    301717 non-null  float64
 6   MentalHealth      301717 non-null  float64
 7   DiffWalking       301717 non-null  int32  
 8   Sex               301717 non-null  int32  
 9   AgeCategory       301717 non-null  object 
 10  Race              301717 non-null  int32  
 11  Diabetic          301717 non-null  int32  
 12  PhysicalActivity  301717 non-null  int32  
 13  GenHealth         301717 non-null  int32  
 14  SleepTime         301717 non-null  float64
 15  Asthma            301717 non-null  int32  
 16  KidneyDisease     301717 non-null  int32  
 17  SkinCancer        301717 non-null  int32  
dtypes: float64(3), int32(13), int64(1), object(1)
memory usage: 28.8+ MB
```

In [22]:
```
colors = ["Pink",'SkyBlue',"Yellow",'#E94B3C','#2D2926']

corr=df_corr.corrwith(df_corr['HeartDisease']).sort_values(ascending=False).to_frame()
corr.columns=['Correlations']
plt.subplots(figsize=(5,10))
sns.heatmap(corr, annot=True, cmap=colors, linewidths=0.4, linecolor='black')
plt.title('Correlation with wrt outcome')
plt.show()
```



In [24]:
```
from sklearn.model_selection import train_test_split
from sklearn.linear_model import LogisticRegression
from sklearn.ensemble import RandomForestClassifier
from sklearn.metrics import accuracy_score, precision_score, recall_score, f1_score, r
from sklearn.preprocessing import StandardScaler
from sklearn.metrics import confusion_matrix
import matplotlib.pyplot as plt
```

```
import seaborn as sns

X = df1.drop('HeartDisease', axis=1)
y = df1['HeartDisease']

# Split the dataset into the training set and test set
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.25, random_state

# Feature scaling for logistic regression
scaler = StandardScaler()
X_train_scaled = scaler.fit_transform(X_train)
X_test_scaled = scaler.transform(X_test)

# Initialize the Logistic Regression model
logreg = LogisticRegression()
# Train the model
logreg.fit(X_train_scaled, y_train)
# Predict on the test set
y_pred_logreg = logreg.predict(X_test_scaled)

# Initialize the Random Forest model
rf = RandomForestClassifier(random_state=0)
# Train the model
rf.fit(X_train, y_train)
# Predict on the test set
y_pred_rf = rf.predict(X_test)

pos_label = 1

# Calculate metrics for Logistic Regression
imbalanced_logreg_metrics = {
    "Accuracy": accuracy_score(y_test, y_pred_logreg),
    "Precision": precision_score(y_test, y_pred_logreg, pos_label=pos_label),
    "Recall": recall_score(y_test, y_pred_logreg, pos_label=pos_label),
    "F1-Score": f1_score(y_test, y_pred_logreg, pos_label=pos_label),
    "AUC": roc_auc_score(y_test, logreg.predict_proba(X_test_scaled)[:, 1])
}

# Calculate metrics for Random Forest
imbalanced_rf_metrics = {
    "Accuracy": accuracy_score(y_test, y_pred_rf),
    "Precision": precision_score(y_test, y_pred_rf, pos_label=pos_label),
    "Recall": recall_score(y_test, y_pred_rf, pos_label=pos_label),
    "F1-Score": f1_score(y_test, y_pred_rf, pos_label=pos_label),
    "AUC": roc_auc_score(y_test, rf.predict_proba(X_test)[:, 1])
}

cm_logreg = confusion_matrix(y_test, y_pred_logreg)
cm_rf = confusion_matrix(y_test, y_pred_rf)
```

In [25]:
```
display(imbalanced_logreg_metrics)
display(cm_logreg)
```

```
{'Accuracy': 0.9105793450881612,
 'Precision': 0.5340236686390533,
 'Recall': 0.10560187216615474,
 'F1-Score': 0.17633410672853828,
 'AUC': 0.829571216956767}
```

```
array([[67963,   630],
       [ 6115,   722]], dtype=int64)
```

In [26]:
```
display(imbalanced_rf_metrics)
display(cm_rf)
```

```
{'Accuracy': 0.9011533872464537,
 'Precision': 0.36857749469214435,
 'Recall': 0.12695626736872898,
 'F1-Score': 0.18885987815491734,
 'AUC': 0.7821740575700927}
array([[67106,  1487],
       [ 5969,   868]], dtype=int64)
```

In [27]:
```
balanced_logreg = LogisticRegression(class_weight='balanced', random_state=0)
balanced_logreg.fit(X_train_scaled, y_train)

#train the balanced Random Forest model
balanced_rf = RandomForestClassifier(class_weight='balanced', random_state=0)
balanced_rf.fit(X_train, y_train)

# Make predictions with both balanced models
y_pred_balanced_logreg = balanced_logreg.predict(X_test_scaled)
y_pred_balanced_rf = balanced_rf.predict(X_test)

# Calculate performance metrics for both balanced models
balanced_metrics_logreg = {
    "Accuracy": accuracy_score(y_test, y_pred_balanced_logreg),
    "Precision": precision_score(y_test, y_pred_balanced_logreg),
    "Recall": recall_score(y_test, y_pred_balanced_logreg),
    "F1-Score": f1_score(y_test, y_pred_balanced_logreg),
    "AUC": roc_auc_score(y_test, balanced_logreg.predict_proba(X_test_scaled)[:, 1])
}

balanced_metrics_rf = {
    "Accuracy": accuracy_score(y_test, y_pred_balanced_rf),
    "Precision": precision_score(y_test, y_pred_balanced_rf),
    "Recall": recall_score(y_test, y_pred_balanced_rf),
    "F1-Score": f1_score(y_test, y_pred_balanced_rf),
    "AUC": roc_auc_score(y_test, balanced_rf.predict_proba(X_test)[:, 1])
}
```

In [28]:
```
display(balanced_metrics_logreg)
```

```
{'Accuracy': 0.7401034071324407,
 'Precision': 0.22519264712213183,
 'Recall': 0.7651016527716835,
 'F1-Score': 0.34796780416417217,
 'AUC': 0.8299289261450331}
```

In [29]:
```
display(balanced_metrics_rf)
```

```
{'Accuracy': 0.8674797825798753,
 'Precision': 0.23023057216054654,
 'Recall': 0.19716249817171275,
 'F1-Score': 0.21241727072171449,
 'AUC': 0.7573243336511979}
```

In [30]:
```
from imblearn.over_sampling import SMOTE
```

```python
# Apply SMOTE to balance the training data
smote = SMOTE(random_state=0)
X_train_smote, y_train_smote = smote.fit_resample(X_train_scaled, y_train)

# Initialize and train the Logistic Regression model with SMOTE
smote_logreg = LogisticRegression(random_state=0)
smote_logreg.fit(X_train_smote, y_train_smote)

# Initialize and train the Random Forest model with SMOTE
smote_rf = RandomForestClassifier(random_state=0)
smote_rf.fit(X_train_smote, y_train_smote)

# Make predictions with both balanced models
y_pred_smote_logreg = smote_logreg.predict(X_test_scaled)
y_pred_smote_rf = smote_rf.predict(X_test_scaled)

# Calculate performance metrics for both balanced models
smote_metrics_logreg = {
    "Accuracy": accuracy_score(y_test, y_pred_smote_logreg),
    "Precision": precision_score(y_test, y_pred_smote_logreg),
    "Recall": recall_score(y_test, y_pred_smote_logreg),
    "F1-Score": f1_score(y_test, y_pred_smote_logreg),
    "AUC": roc_auc_score(y_test, smote_logreg.predict_proba(X_test_scaled)[:, 1])
}

smote_metrics_rf = {
    "Accuracy": accuracy_score(y_test, y_pred_smote_rf),
    "Precision": precision_score(y_test, y_pred_smote_rf),
    "Recall": recall_score(y_test, y_pred_smote_rf),
    "F1-Score": f1_score(y_test, y_pred_smote_rf),
    "AUC": roc_auc_score(y_test, smote_rf.predict_proba(X_test_scaled)[:, 1])
}
```

In [31]:
```python
display(smote_metrics_logreg)
```

```
{'Accuracy': 0.7401299217817844,
 'Precision': 0.22497522299306244,
 'Recall': 0.763639022963288,
 'F1-Score': 0.34755691652243376,
 'AUC': 0.8287304431049297}
```

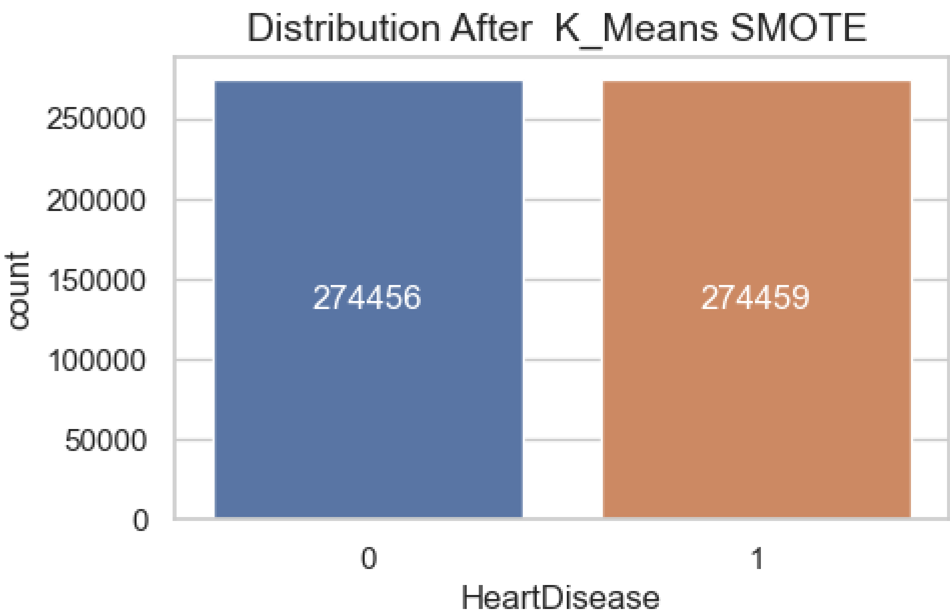
In [32]:
```python
display(smote_metrics_rf)
```

```
{'Accuracy': 0.8791329709664589,
 'Precision': 0.290979097909791,
 'Recall': 0.23211935059236508,
 'F1-Score': 0.2582377349279961,
 'AUC': 0.7786520640545156}
```

In [ ]:
```python

```

In [73]:
```python
from  imblearn.over_sampling import KMeansSMOTE

KSMOTE  = KMeansSMOTE(cluster_balance_threshold=0.1)
X_KSMOTE, y_KSMOTE = KSMOTE.fit_resample(X, y)


plt.figure(figsize = (5,3))
ax=sns.countplot( x = y_KSMOTE )
for container in ax.containers:
```

```
    ax.bar_label(container, label_type='center', rotation=0, color='white')
plt.title("Distribution After  K_Means SMOTE ", size=14)
plt.show()
```



In [34]:

```
from sklearn.model_selection import train_test_split
X_train , X_test, y_train,  y_test = train_test_split(X_KSMOTE, y_KSMOTE , test_size=0

scaler= StandardScaler()
scaler.fit(X_train)
X_train_scaled = scaler.transform(X_train)
X_test_scaled = scaler.transform(X_test)

logreg_s=LogisticRegression(solver="liblinear", penalty="l2", C=0.00001, max_iter=1000
logreg_s.fit(X_train_scaled,y_train)
y_pred_log=logreg_s.predict(X_test_scaled)

y_pred_proba_log = logreg_s.predict_proba(X_test_scaled)


KSMOTE_log_metrics = {
    "Accuracy": accuracy_score(y_test, y_pred_log),
    "Precision": precision_score(y_test, y_pred_log),
    "Recall": recall_score(y_test, y_pred_log),
    "F1-Score": f1_score(y_test, y_pred_log),
    "AUC": roc_auc_score(y_test, y_pred_proba_log[:, 1])
}

display(KSMOTE_log_metrics)
```

```
{'Accuracy': 0.9036865385596339,
 'Precision': 0.9053528620709816,
 'Recall': 0.9018331658876804,
 'F1-Score': 0.9035895864790541,
 'AUC': 0.9569976186746174}
```

In [74]:

```
df_logreg = pd.DataFrame([imbalanced_logreg_metrics], index=['LogReg_Imbalanced'])
df_rf = pd.DataFrame([imbalanced_rf_metrics], index=['RF_Imbalanced'])
df_balanced_logreg = pd.DataFrame([balanced_metrics_logreg], index=['LogReg_Balanced']
df_imbalanced_rf = pd.DataFrame([balanced_metrics_logreg], index=['RF_Balanced'])
df_smote_logreg = pd.DataFrame([smote_metrics_logreg], index=['LogReg_Smote'])
```

```
df_smote_rf = pd.DataFrame([smote_metrics_rf], index=['RF_Smote'])
df_KSMOTE_logreg = pd.DataFrame([KSMOTE_log_metrics], index=['LogReg_KSmote'])

simple_model = pd.concat([df_logreg, df_rf, df_balanced_logreg, df_imbalanced_rf, df_s
compare_model = simple_model.transpose()

compare_model
```

Out[74]:

	LogReg_Imbalanced	RF_Imbalanced	LogReg_Balanced	RF_Balanced	LogReg_Smote	RF_Smo
Accuracy	0.910579	0.901153	0.740103	0.740103	0.740130	0.8791
Precision	0.534024	0.368577	0.225193	0.225193	0.224975	0.2909
Recall	0.105602	0.126956	0.765102	0.765102	0.763639	0.2321
F1-Score	0.176334	0.188860	0.347968	0.347968	0.347557	0.2582
AUC	0.829571	0.782174	0.829929	0.829929	0.828730	0.7786

In [39]:

```
import pickle
```

In [40]:

```
projectfile = 'trained_model.sav'
pickle.dump(logreg_s, open(projectfile, 'wb'))
```

In [69]:

```
loaded_model = pickle.load(open('trained_model.sav', 'rb'))
```