Train Data

In [85]:

```
import pandas as pd    # package for data analysis
import numpy as np     # package for numerical computations

# libraries for visualization
import matplotlib.pyplot as plt
import seaborn as sns

# to ignore warnings
import warnings
warnings.filterwarnings('ignore')

# For Preprocessing, ML models and Evaluation
from sklearn.model_selection import train_test_split    # To split the dataset into train
and test set

from sklearn.linear_model import LogisticRegression      # Logistic regression model

from sklearn import preprocessing
from sklearn.preprocessing import LabelEncoder     # for converting categorical to numeric
al

from sklearn.metrics import f1_score     # for model evaluation
```

In [26]:

```
data = pd.read_csv('https://raw.githubusercontent.com/dphi-official/Datasets/master/pharm
a_data/Training_set_begs.csv')
```

In [27]:

```
data.head()
```

Out[27]:

	ID_Patient_Care_Situation	Diagnosed_Condition	Patient_ID	Treated_with_drugs	Patient_Age	Patient_Body_Mass_Index	Pat
0	**22374**	**8**	**3333**	**DX6**	**56**	**18.479385**	
1	**18164**	**5**	**5740**	**DX2**	**36**	**22.945566**	
2	**6283**	**23**	**10446**	**DX6**	**48**	**27.510027**	
3	**5339**	**51**	**12011**	**DX1**	**5**	**19.130976**	
4	**33012**	**0**	**12513**	**NaN**	**128**	**1.348400**	

In [28]:

```
data.Treated_with_drugs.value_counts()
```

Out[28]:

```
DX6                    8606
DX5                    1909
DX2                    1904
DX1                    1835
DX3                    1830
DX4                    1792
DX3 DX4                 448
DX1 DX2                 448
DX1 DX3                 424
DX4 DX5                 423
DX2 DX4                 419
DX1 DX4                 408
```

```
DX1 DX4                  408
DX3 DX5                  407
DX1 DX5                  402
DX2 DX5                  400
DX2 DX3                  398
DX1 DX2 DX5              103
DX1 DX3 DX5              101
DX1 DX2 DX4               99
DX3 DX4 DX5               96
DX1 DX2 DX3               95
DX2 DX3 DX5               91
DX1 DX3 DX4               90
DX2 DX3 DX4               87
DX2 DX4 DX5               84
DX1 DX4 DX5               80
DX1 DX2 DX3 DX4           24
DX1 DX3 DX4 DX5           24
DX2 DX3 DX4 DX5           22
DX1 DX2 DX4 DX5           18
DX1 DX2 DX3 DX5           14
DX1 DX2 DX3 DX4 DX5        3
Name: Treated_with_drugs, dtype: int64
```

In [29]:

```
data['Treated_with_drugs'] = data['Treated_with_drugs'].str.upper()
```

In [30]:

```
data.Patient_Smoker.value_counts()
```

Out[30]:

```
NO            13246
YES            9838
Cannot say       13
Name: Patient_Smoker, dtype: int64
```

In [31]:

```
def smoker(r):
  if (r == "NO") or (r == "NO "):
    return 'NO'
  elif (r == "YES") or (r == "YES ") or (r == "YESS") or (r == "YESS "):
    return 'YES'
  else:
    return 'Cannot say'

data.Patient_Smoker = data.Patient_Smoker.apply(smoker)  # Applying the function
```

In [32]:

```
data.Patient_Rural_Urban.value_counts()
```

Out[32]:

```
RURAL    16134
URBAN     6963
Name: Patient_Rural_Urban, dtype: int64
```

In [24]:

```
data.Patient_mental_condition.value_counts()
```

Out[24]:

```
Stable    23097
Name: Patient_mental_condition, dtype: int64
```

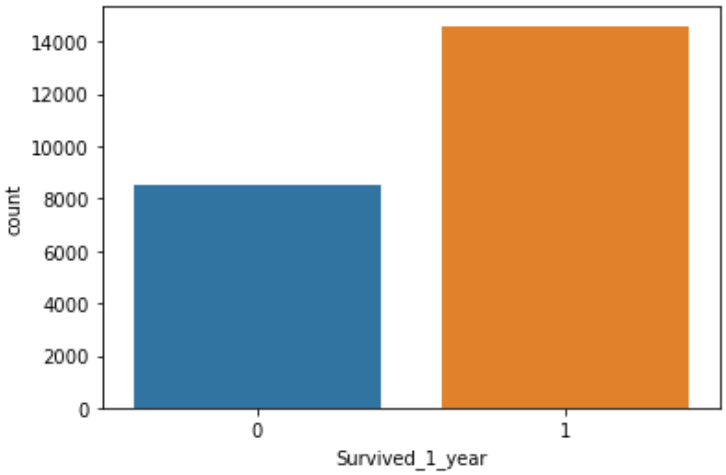
In [33]:

```
data.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 23097 entries, 0 to 23096
Data columns (total 18 columns):
 #   Column                      Non-Null Count  Dtype  
---  ------                      --------------  -----  
 0   ID_Patient_Care_Situation   23097 non-null  int64  
 1   Diagnosed_Condition         23097 non-null  int64  
 2   Patient_ID                  23097 non-null  int64  
 3   Treated_with_drugs          23084 non-null  object 
 4   Patient_Age                 23097 non-null  int64  
 5   Patient_Body_Mass_Index     23097 non-null  float64
 6   Patient_Smoker              23097 non-null  object 
 7   Patient_Rural_Urban         23097 non-null  object 
 8   Patient_mental_condition    23097 non-null  object 
 9   A                           21862 non-null  float64
 10  B                           21862 non-null  float64
 11  C                           21862 non-null  float64
 12  D                           21862 non-null  float64
 13  E                           21862 non-null  float64
 14  F                           21862 non-null  float64
 15  Z                           21862 non-null  float64
 16  Number_of_prev_cond         21862 non-null  float64
 17  Survived_1_year             23097 non-null  int64  
dtypes: float64(9), int64(5), object(4)
memory usage: 3.2+ MB
```

In [34]:

```
sns.countplot(x='Survived_1_year', data=data)
plt.show()
```



In [35]:

```
numeric_features = data.select_dtypes(include=[np.number])    # select_dtypes helps you to select data of particular types
numeric_features.columns
```

Out[35]:

```
Index(['ID_Patient_Care_Situation', 'Diagnosed_Condition', 'Patient_ID',
       'Patient_Age', 'Patient_Body_Mass_Index', 'A', 'B', 'C', 'D', 'E', 'F',
       'Z', 'Number_of_prev_cond', 'Survived_1_year'],
      dtype='object')
```

In [36]:

```
numeric_data=data[['Diagnosed_Condition', 'Patient_Age', 'Patient_Body_Mass_Index', 'Number_of_prev_cond', 'Survived_1_year']]  #keeping in the target varibale for analysis purposes
numeric_data.head()
```

Out[36]:

	Diagnosed_Condition	Patient_Age	Patient_Body_Mass_Index	Number_of_prev_cond	Survived_1_year
0	8	56	18.479385	2.0	0

	Diagnosed_Condition	Patient_Age	Patient_Body_Mass_Index	Number_of_prev_cond	Survived_1_year
1	5	36	22.945566	1.0	1
2	23	48	27.510027	1.0	0
3	51	5	19.130976	1.0	1
4	0	128	1.348400	1.0	1

In [37]:

```
numeric_data.isnull().sum()
```

Out[37]:

```
Diagnosed_Condition            0
Patient_Age                    0
Patient_Body_Mass_Index        0
Number_of_prev_cond         1235
Survived_1_year                0
dtype: int64
```

In [38]:

```
data['Number_of_prev_cond'] = data['Number_of_prev_cond'].fillna(data['Number_of_prev_cond'].mode()[0])  # filling the missing value of 'Number_of_prev_cond'

numeric_data['Number_of_prev_cond']=data['Number_of_prev_cond']
numeric_data.isnull().sum()
```

Out[38]:

```
Diagnosed_Condition         0
Patient_Age                 0
Patient_Body_Mass_Index     0
Number_of_prev_cond         0
Survived_1_year             0
dtype: int64
```

In [39]:

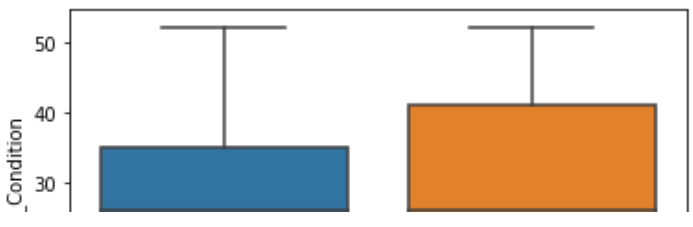
```
numeric_data.describe()
```

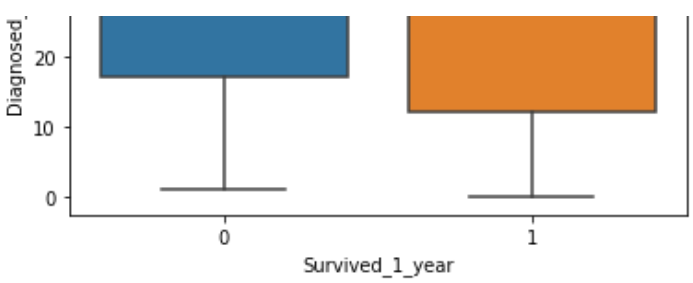
Out[39]:

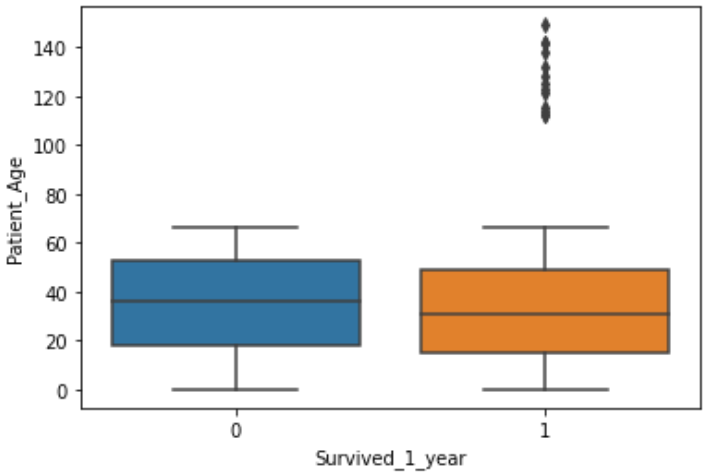
	Diagnosed_Condition	Patient_Age	Patient_Body_Mass_Index	Number_of_prev_cond	Survived_1_year
count	23097.000000	23097.000000	23097.000000	23097.000000	23097.000000
mean	26.413127	33.209768	23.454820	1.710352	0.632247
std	15.030865	19.549882	3.807661	0.768216	0.482204
min	0.000000	0.000000	1.089300	1.000000	0.000000
25%	13.000000	16.000000	20.205550	1.000000	0.000000
50%	26.000000	33.000000	23.386199	2.000000	1.000000
75%	39.000000	50.000000	26.788154	2.000000	1.000000
max	52.000000	149.000000	29.999579	5.000000	1.000000

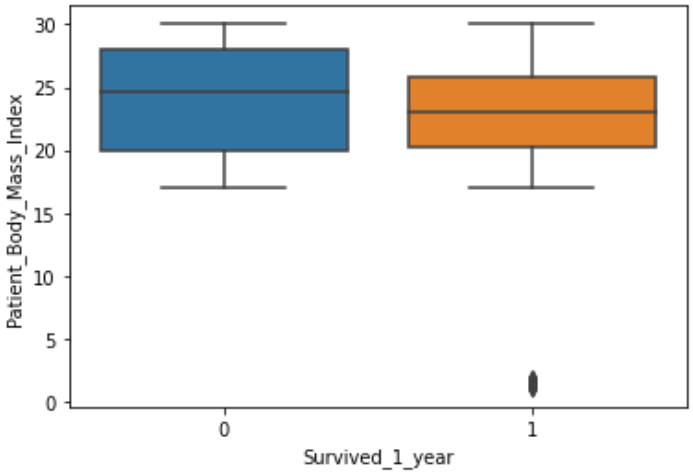
In [40]:

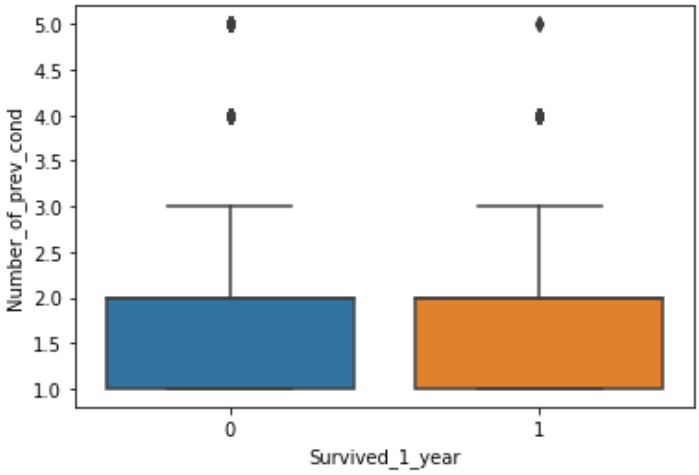
```
for feature in numeric_data.drop('Survived_1_year', axis = 1).columns:
  sns.boxplot(x='Survived_1_year', y=feature, data=numeric_data)
  plt.show()
```





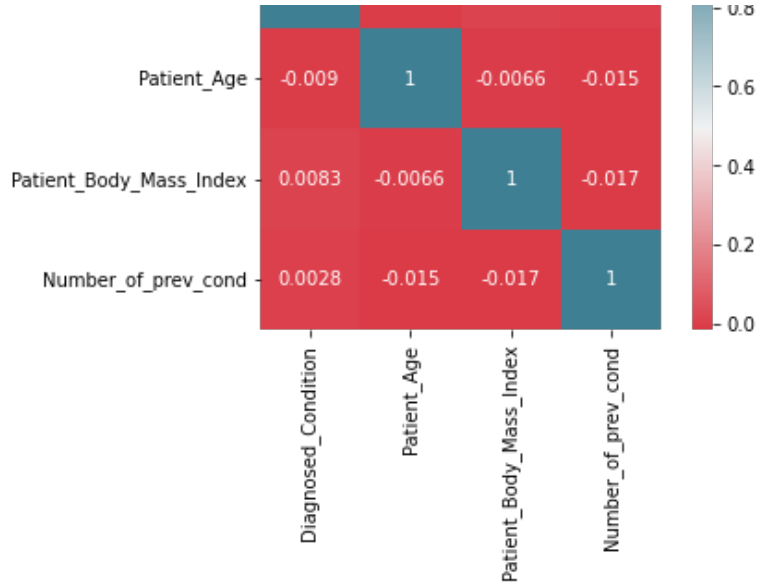






In [41]:

```
numeric_data=numeric_data.drop(['Survived_1_year'], axis=1)
colormap = sns.diverging_palette(10, 220, as_cmap = True)
sns.heatmap(numeric_data.corr(),
            cmap = colormap,
            square = True,
            annot = True)
plt.show()
```



In [42]:

```
data.isnull().sum()
```

Out[42]:

```
ID_Patient_Care_Situation       0
Diagnosed_Condition             0
Patient_ID                      0
Treated_with_drugs             13
Patient_Age                     0
Patient_Body_Mass_Index         0
Patient_Smoker                  0
Patient_Rural_Urban             0
Patient_mental_condition        0
A                            1235
B                            1235
C                            1235
D                            1235
E                            1235
F                            1235
Z                            1235
Number_of_prev_cond             0
Survived_1_year                 0
dtype: int64
```

In [43]:

```
data['Treated_with_drugs']=data['Treated_with_drugs'].fillna(data['Treated_with_drugs'].mode()[0])
```

In [44]:

```
data['A'].fillna(data['A'].mode()[0], inplace = True)
data['B'].fillna(data['B'].mode()[0], inplace = True)
data['C'].fillna(data['C'].mode()[0], inplace = True)
data['D'].fillna(data['D'].mode()[0], inplace = True)
data['E'].fillna(data['E'].mode()[0], inplace = True)
data['F'].fillna(data['F'].mode()[0], inplace = True)
data['Z'].fillna(data['Z'].mode()[0], inplace = True)
```

In [45]:

```
data.isnull().sum()
```

Out[45]:

```
ID_Patient_Care_Situation    0
Diagnosed_Condition          0
Patient_ID                   0
Treated_with_drugs           0
Patient_Age                  0
```

```
Patient_Body_Mass_Index       0
Patient_Smoker                0
Patient_Rural_Urban           0
Patient_mental_condition      0
A                             0
B                             0
C                             0
D                             0
E                             0
F                             0
Z                             0
Number_of_prev_cond           0
Survived_1_year               0
dtype: int64
```

In [46]:

```
categorical_data = data.drop(numeric_data.columns, axis=1)     # dropping the numerical c
olumns from the dataframe 'data'
categorical_data.drop(['Patient_ID', 'ID_Patient_Care_Situation'], axis=1, inplace = Tru
e)     # dropping the id columns form the dataframe 'categorical data'
categorical_data.head()     # Now we are left with categorical columns only. take a look a
t first five observaitons
```

Out[46]:

	Treated_with_drugs	Patient_Smoker	Patient_Rural_Urban	Patient_mental_condition	A	B	C	D	E	F	Z	Survive
0	DX6	YES	URBAN	Stable	1.0	0.0	0.0	0.0	1.0	0.0	0.0	
1	DX2	YES	RURAL	Stable	1.0	0.0	0.0	0.0	0.0	0.0	0.0	
2	DX6	YES	RURAL	Stable	1.0	0.0	0.0	0.0	0.0	0.0	0.0	
3	DX1	NO	URBAN	Stable	1.0	0.0	0.0	0.0	0.0	0.0	0.0	
4	DX6	Cannot say	RURAL	Stable	0.0	0.0	0.0	0.0	0.0	0.0	1.0	

In [47]:

```
categorical_data.nunique()    # nunique() return you the number of unique values in each
column/feature
```

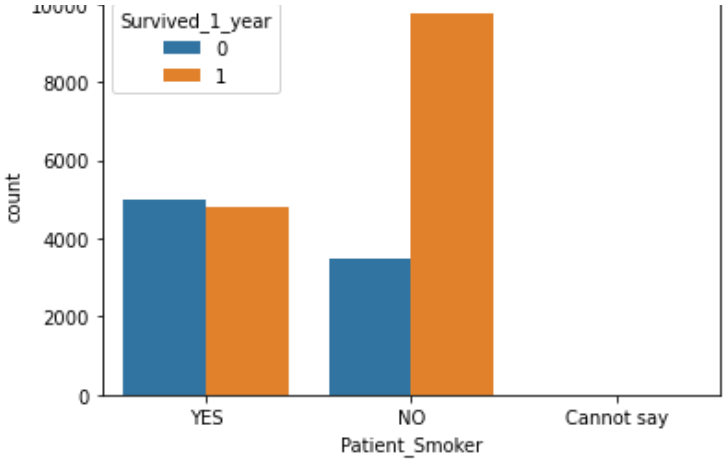
Out[47]:

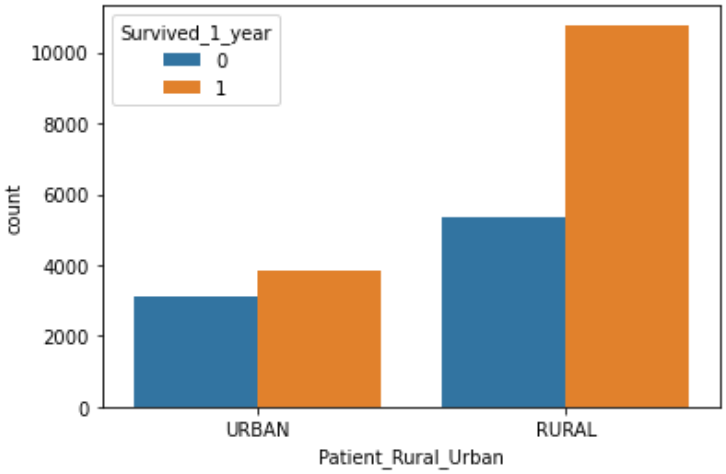
```
Treated_with_drugs           32
Patient_Smoker                3
Patient_Rural_Urban           2
Patient_mental_condition      1
A                             2
B                             2
C                             2
D                             2
E                             2
F                             2
Z                             2
Survived_1_year               2
dtype: int64
```

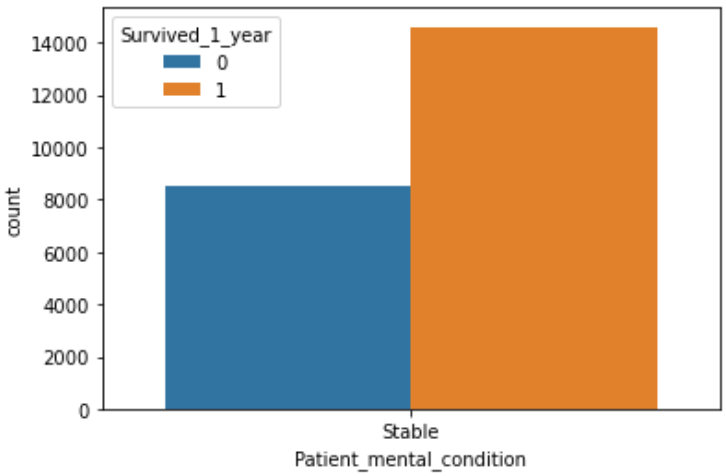
In [48]:

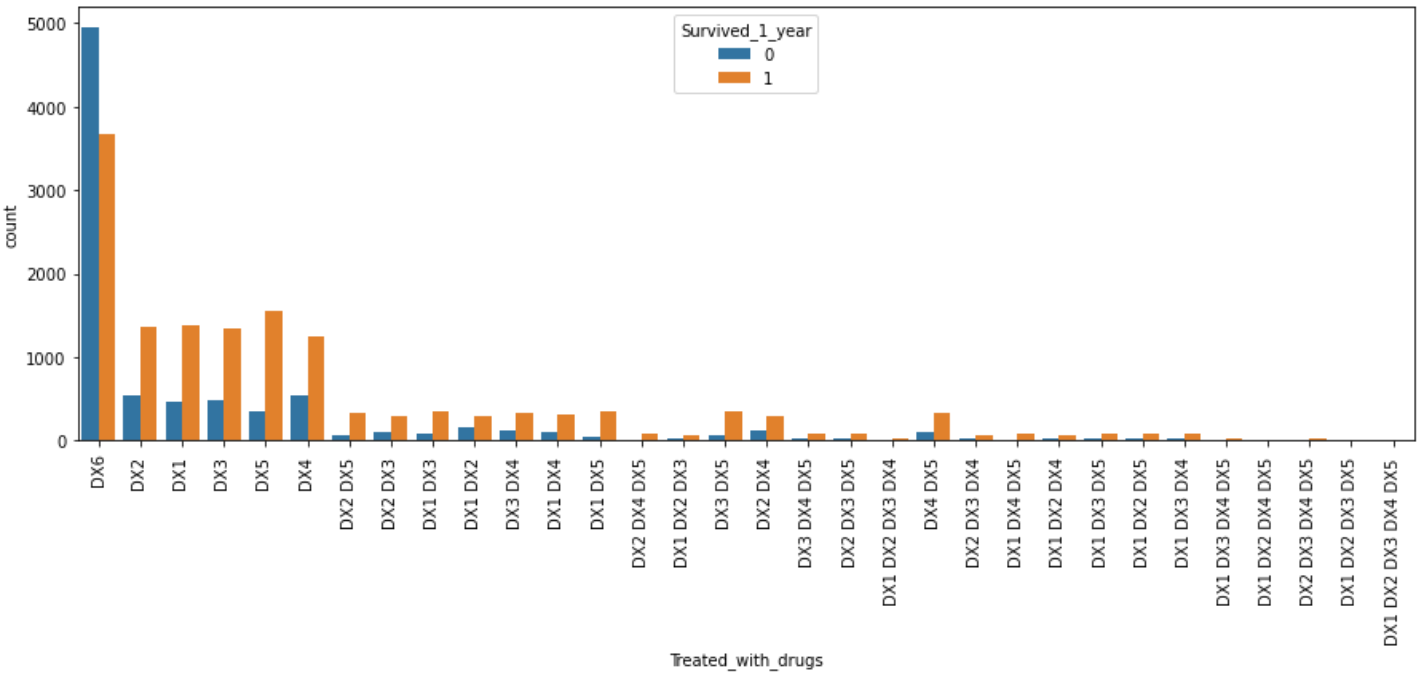
```
# Visualization of categorical columns
for feature in ['Patient_Smoker', 'Patient_Rural_Urban', 'Patient_mental_condition']:
  sns.countplot(x=feature,  hue='Survived_1_year', data=categorical_data)
  plt.show()


plt.figure(figsize=(15,5))
sns.countplot(x='Treated_with_drugs',  hue='Survived_1_year', data=categorical_data)
plt.xticks(rotation=90)
plt.show()
```


Survived_1_year
0
1
count
0
2000
4000
6000
8000
10000
YES
NO
Cannot say
Patient_Smoker


Survived_1_year
0
1
count
0
2000
4000
6000
8000
10000
URBAN
RURAL
Patient_Rural_Urban


Survived_1_year
0
1
count
0
2000
4000
6000
8000
10000
12000
14000
Stable
Patient_mental_condition


Survived_1_year
0
1
count
0
1000
2000
3000
4000
5000
DX6
DX2
DX1
DX3
DX5
DX4
DX2 DX5
DX2 DX3
DX1 DX3
DX1 DX2
DX3 DX4
DX1 DX4
DX1 DX5
DX2 DX4 DX5
DX1 DX2 DX3
DX3 DX5
DX2 DX4
DX3 DX4 DX5
DX2 DX3 DX5
DX1 DX2 DX3 DX4
DX4 DX5
DX2 DX3 DX4
DX1 DX4 DX5
DX1 DX2 DX4
DX1 DX3 DX5
DX1 DX2 DX5
DX1 DX3 DX4
DX1 DX3 DX4 DX5
DX1 DX2 DX4 DX5
DX2 DX3 DX4 DX5
DX1 DX2 DX3 DX5
DX1 DX2 DX3 DX4 DX5
Treated_with_drugs

In [49]:

```
drugs = data['Treated_with_drugs'].str.get_dummies(sep=' ') # split all the entries separated by space and create dummy variable
drugs.head()
```

Out[49]:

	DX1	DX2	DX3	DX4	DX5	DX6
0	0	0	0	0	0	1
1	0	1	0	0	0	0
2	0	0	0	0	0	1
3	1	0	0	0	0	0
4	0	0	0	0	0	1

In [50]:

```
data = pd.concat([data, drugs], axis=1)      # concat the two dataframes 'drugs' and 'data'
data = data.drop('Treated_with_drugs', axis=1)     # dropping the column 'Treated_with_drugs' as its values are now splitted into different columns

data.head()
```

Out[50]:

	ID_Patient_Care_Situation	Diagnosed_Condition	Patient_ID	Patient_Age	Patient_Body_Mass_Index	Patient_Smoker	Patient
0	22374	8	3333	56	18.479385	YES	
1	18164	5	5740	36	22.945566	YES	
2	6283	23	10446	48	27.510027	YES	
3	5339	51	12011	5	19.130976	NO	
4	33012	0	12513	128	1.348400	Cannot say	

In [51]:

```
data.Patient_Smoker.value_counts()
```

Out[51]:

```
NO            13246
YES            9838
Cannot say       13
Name: Patient_Smoker, dtype: int64
```

In [52]:

```
data.Patient_Smoker[data['Patient_Smoker'] == "Cannot say"] = 'NO'
```

In [53]:

```
data.drop('Patient_mental_condition', axis = 1, inplace=True)
```

In [54]:

```
data = pd.get_dummies(data, columns=['Patient_Smoker', 'Patient_Rural_Urban'])
```

In [55]:

```
data.head()
```

Out[55]:

	ID_Patient_Care_Situation	Diagnosed_Condition	Patient_ID	Patient_Age	Patient_Body_Mass_Index	A	B	C	D	E	..

	ID_Patient_Care_Situation	Diagnosed_Condition	Patient_ID	Patient_Age	Patient_Body_Mass_Index	A	B	C	D	E	
0	22374	8	3333	56	18.479385	1.0	0.0	0.0	0.0	1.0	..
1	18164	5	5740	36	22.945566	1.0	0.0	0.0	0.0	0.0	..
2	6283	23	10446	48	27.510027	1.0	0.0	0.0	0.0	0.0	..
3	5339	51	12011	5	19.130976	1.0	0.0	0.0	0.0	0.0	..
4	33012	0	12513	128	1.348400	0.0	0.0	0.0	0.0	0.0	..

In [56]:

```
data.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 23097 entries, 0 to 23096
Data columns (total 24 columns):
 #   Column                      Non-Null Count  Dtype  
---  ------                      --------------  -----  
 0   ID_Patient_Care_Situation   23097 non-null  int64  
 1   Diagnosed_Condition         23097 non-null  int64  
 2   Patient_ID                  23097 non-null  int64  
 3   Patient_Age                 23097 non-null  int64  
 4   Patient_Body_Mass_Index     23097 non-null  float64
 5   A                           23097 non-null  float64
 6   B                           23097 non-null  float64
 7   C                           23097 non-null  float64
 8   D                           23097 non-null  float64
 9   E                           23097 non-null  float64
 10  F                           23097 non-null  float64
 11  Z                           23097 non-null  float64
 12  Number_of_prev_cond         23097 non-null  float64
 13  Survived_1_year             23097 non-null  int64  
 14  DX1                         23097 non-null  int64  
 15  DX2                         23097 non-null  int64  
 16  DX3                         23097 non-null  int64  
 17  DX4                         23097 non-null  int64  
 18  DX5                         23097 non-null  int64  
 19  DX6                         23097 non-null  int64  
 20  Patient_Smoker_NO           23097 non-null  uint8  
 21  Patient_Smoker_YES          23097 non-null  uint8  
 22  Patient_Rural_Urban_RURAL   23097 non-null  uint8  
 23  Patient_Rural_Urban_URBAN   23097 non-null  uint8  
dtypes: float64(9), int64(11), uint8(4)
memory usage: 3.6 MB
```

In [57]:

```
print(data.ID_Patient_Care_Situation.nunique())     # nunique() gives you the count of un
ique values in the column
print(data.Patient_ID.nunique())
```

```
23097
10570
```

In [58]:

```
data.drop(['ID_Patient_Care_Situation'], axis =1, inplace=True)
```

In [59]:

```
X = data.drop('Survived_1_year',axis = 1)
y = data['Survived_1_year']
```

In [60]:

```
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2, random_state=1)
```

Linear Regression

In [61]:

```
model = LogisticRegression(max_iter = 1000)      # The maximum number of iterations will b
e 1000. This will help you prevent from convergence warning.
model.fit(X_train,y_train)
```

Out[61]:

```
LogisticRegression(max_iter=1000)
```

In [62]:

```
pred = model.predict(X_test)
```

In [63]:

```
print(f1_score(y_test,pred))
```

```
0.7874015748031497
```

Random Forest

In [64]:

```
from sklearn.feature_selection import SelectFromModel
from sklearn.metrics import accuracy_score, f1_score
from sklearn.ensemble import RandomForestClassifier
```

In [65]:

```
forest = RandomForestClassifier(random_state=1, n_estimators=1000, max_depth=5)

forest.fit(X_train, y_train)
```

Out[65]:

```
RandomForestClassifier(max_depth=5, n_estimators=1000, random_state=1)
```

In [66]:

```
y_pred = forest.predict(X_test)

fscore = f1_score(y_test ,y_pred)
fscore
```

Out[66]:

```
0.8220447284345048
```

Random Forest and Boruta

In [67]:

```
!pip install Boruta
```

```
Collecting Boruta
  Downloading Boruta-0.3-py3-none-any.whl (56 kB)
     |████████████████████████████████| 56 kB 1.3 MB/s eta 0:00:01
Requirement already satisfied: scipy>=0.17.0 in /Users/jay/opt/anaconda3/lib/python3.9/si
te-packages (from Boruta) (1.7.1)
Requirement already satisfied: numpy>=1.10.4 in /Users/jay/opt/anaconda3/lib/python3.9/si
te-packages (from Boruta) (1.20.3)
Requirement already satisfied: scikit-learn>=0.17.1 in /Users/jay/opt/anaconda3/lib/pytho
n3.9/site-packages (from Boruta) (0.24.2)
Requirement already satisfied: joblib>=0.11 in /Users/jay/opt/anaconda3/lib/python3.9/sit
e-packages (from scikit-learn>=0.17.1->Boruta) (1.1.0)
Requirement already satisfied: threadpoolctl>=2.0.0 in /Users/jay/opt/anaconda3/lib/pytho
n3.9/site-packages (from scikit-learn>=0.17.1->Boruta) (2.2.0)
```

```
Installing collected packages: Boruta
Successfully installed Boruta-0.3
```

In [68]:

```
from boruta import BorutaPy
```

In [69]:

```
boruta_selector = BorutaPy(forest, n_estimators='auto', verbose=2, random_state=1)   # initialize the boruta selector
boruta_selector.fit(np.array(X_train), np.array(y_train))       #
```

```
Iteration:  1 / 100
Confirmed:  0
Tentative:  22
Rejected:  0
Iteration:  2 / 100
Confirmed:  0
Tentative:  22
Rejected:  0
Iteration:  3 / 100
Confirmed:  0
Tentative:  22
Rejected:  0
Iteration:  4 / 100
Confirmed:  0
Tentative:  22
Rejected:  0
Iteration:  5 / 100
Confirmed:  0
Tentative:  22
Rejected:  0
Iteration:  6 / 100
Confirmed:  0
Tentative:  22
Rejected:  0
Iteration:  7 / 100
Confirmed:  0
Tentative:  22
Rejected:  0
Iteration:  8 / 100
Confirmed:  16
Tentative:  3
Rejected:  3
Iteration:  9 / 100
Confirmed:  16
Tentative:  3
Rejected:  3
Iteration:  10 / 100
Confirmed:  16
Tentative:  3
Rejected:  3
Iteration:  11 / 100
Confirmed:  16
Tentative:  3
Rejected:  3
Iteration:  12 / 100
Confirmed:  16
Tentative:  3
Rejected:  3
Iteration:  13 / 100
Confirmed:  16
Tentative:  3
Rejected:  3
Iteration:  14 / 100
Confirmed:  16
Tentative:  3
Rejected:  3
Iteration:  15 / 100
Confirmed:  16
Tentative:  3
```

```
Rejected:  3
Iteration:  16 / 100
Confirmed:  16
Tentative:  3
Rejected:  3
Iteration:  17 / 100
Confirmed:  16
Tentative:  3
Rejected:  3
Iteration:  18 / 100
Confirmed:  16
Tentative:  3
Rejected:  3
Iteration:  19 / 100
Confirmed:  16
Tentative:  3
Rejected:  3
Iteration:  20 / 100
Confirmed:  16
Tentative:  3
Rejected:  3
Iteration:  21 / 100
Confirmed:  16
Tentative:  3
Rejected:  3
Iteration:  22 / 100
Confirmed:  16
Tentative:  3
Rejected:  3
Iteration:  23 / 100
Confirmed:  16
Tentative:  3
Rejected:  3
Iteration:  24 / 100
Confirmed:  16
Tentative:  3
Rejected:  3
Iteration:  25 / 100
Confirmed:  16
Tentative:  3
Rejected:  3
Iteration:  26 / 100
Confirmed:  16
Tentative:  3
Rejected:  3
Iteration:  27 / 100
Confirmed:  16
Tentative:  3
Rejected:  3
Iteration:  28 / 100
Confirmed:  16
Tentative:  3
Rejected:  3
Iteration:  29 / 100
Confirmed:  16
Tentative:  3
Rejected:  3
Iteration:  30 / 100
Confirmed:  16
Tentative:  3
Rejected:  3
Iteration:  31 / 100
Confirmed:  16
Tentative:  3
Rejected:  3
Iteration:  32 / 100
Confirmed:  17
Tentative:  2
Rejected:  3
Iteration:  33 / 100
Confirmed:  17
Tentative:  2
```

```
Rejected:  3
Iteration:  34 / 100
Confirmed:  17
Tentative:  2
Rejected:  3
Iteration:  35 / 100
Confirmed:  17
Tentative:  2
Rejected:  3
Iteration:  36 / 100
Confirmed:  17
Tentative:  2
Rejected:  3
Iteration:  37 / 100
Confirmed:  17
Tentative:  2
Rejected:  3
Iteration:  38 / 100
Confirmed:  17
Tentative:  2
Rejected:  3
Iteration:  39 / 100
Confirmed:  17
Tentative:  2
Rejected:  3
Iteration:  40 / 100
Confirmed:  17
Tentative:  2
Rejected:  3
Iteration:  41 / 100
Confirmed:  17
Tentative:  2
Rejected:  3
Iteration:  42 / 100
Confirmed:  17
Tentative:  2
Rejected:  3
Iteration:  43 / 100
Confirmed:  17
Tentative:  2
Rejected:  3
Iteration:  44 / 100
Confirmed:  17
Tentative:  2
Rejected:  3
Iteration:  45 / 100
Confirmed:  17
Tentative:  2
Rejected:  3
Iteration:  46 / 100
Confirmed:  17
Tentative:  2
Rejected:  3
Iteration:  47 / 100
Confirmed:  17
Tentative:  2
Rejected:  3
Iteration:  48 / 100
Confirmed:  17
Tentative:  2
Rejected:  3
Iteration:  49 / 100
Confirmed:  17
Tentative:  2
Rejected:  3
Iteration:  50 / 100
Confirmed:  17
Tentative:  2
Rejected:  3
Iteration:  51 / 100
Confirmed:  17
Tentative:  2
```

```
Rejected:  3
Iteration:  52 / 100
Confirmed:  17
Tentative:  2
Rejected:  3
Iteration:  53 / 100
Confirmed:  17
Tentative:  2
Rejected:  3
Iteration:  54 / 100
Confirmed:  17
Tentative:  2
Rejected:  3
Iteration:  55 / 100
Confirmed:  17
Tentative:  2
Rejected:  3
Iteration:  56 / 100
Confirmed:  17
Tentative:  2
Rejected:  3
Iteration:  57 / 100
Confirmed:  17
Tentative:  2
Rejected:  3
Iteration:  58 / 100
Confirmed:  17
Tentative:  2
Rejected:  3
Iteration:  59 / 100
Confirmed:  17
Tentative:  2
Rejected:  3
Iteration:  60 / 100
Confirmed:  17
Tentative:  2
Rejected:  3
Iteration:  61 / 100
Confirmed:  17
Tentative:  2
Rejected:  3
Iteration:  62 / 100
Confirmed:  17
Tentative:  2
Rejected:  3
Iteration:  63 / 100
Confirmed:  17
Tentative:  2
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Iteration:  64 / 100
Confirmed:  17
Tentative:  2
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Iteration:  65 / 100
Confirmed:  17
Tentative:  2
Rejected:  3
Iteration:  66 / 100
Confirmed:  17
Tentative:  2
Rejected:  3
Iteration:  67 / 100
Confirmed:  17
Tentative:  2
Rejected:  3
Iteration:  68 / 100
Confirmed:  17
Tentative:  2
Rejected:  3
Iteration:  69 / 100
Confirmed:  17
Tentative:  2
```

```
Rejected:  3
Iteration:  70 / 100
Confirmed:  17
Tentative:  2
Rejected:  3
Iteration:  71 / 100
Confirmed:  17
Tentative:  2
Rejected:  3
Iteration:  72 / 100
Confirmed:  17
Tentative:  2
Rejected:  3
Iteration:  73 / 100
Confirmed:  17
Tentative:  2
Rejected:  3
Iteration:  74 / 100
Confirmed:  17
Tentative:  2
Rejected:  3
Iteration:  75 / 100
Confirmed:  17
Tentative:  2
Rejected:  3
Iteration:  76 / 100
Confirmed:  17
Tentative:  2
Rejected:  3
Iteration:  77 / 100
Confirmed:  17
Tentative:  2
Rejected:  3
Iteration:  78 / 100
Confirmed:  17
Tentative:  2
Rejected:  3
Iteration:  79 / 100
Confirmed:  17
Tentative:  2
Rejected:  3
Iteration:  80 / 100
Confirmed:  17
Tentative:  2
Rejected:  3
Iteration:  81 / 100
Confirmed:  17
Tentative:  2
Rejected:  3
Iteration:  82 / 100
Confirmed:  17
Tentative:  2
Rejected:  3
Iteration:  83 / 100
Confirmed:  17
Tentative:  2
Rejected:  3
Iteration:  84 / 100
Confirmed:  17
Tentative:  2
Rejected:  3
Iteration:  85 / 100
Confirmed:  17
Tentative:  2
Rejected:  3
Iteration:  86 / 100
Confirmed:  17
Tentative:  2
Rejected:  3
Iteration:  87 / 100
Confirmed:  17
Tentative:  2
```

```
Rejected:  3
Iteration:  88 / 100
Confirmed:  17
Tentative:  2
Rejected:  3
Iteration:  89 / 100
Confirmed:  17
Tentative:  2
Rejected:  3
Iteration:  90 / 100
Confirmed:  17
Tentative:  2
Rejected:  3
Iteration:  91 / 100
Confirmed:  17
Tentative:  2
Rejected:  3
Iteration:  92 / 100
Confirmed:  17
Tentative:  2
Rejected:  3
Iteration:  93 / 100
Confirmed:  17
Tentative:  2
Rejected:  3
Iteration:  94 / 100
Confirmed:  17
Tentative:  2
Rejected:  3
Iteration:  95 / 100
Confirmed:  17
Tentative:  2
Rejected:  3
Iteration:  96 / 100
Confirmed:  17
Tentative:  2
Rejected:  3
Iteration:  97 / 100
Confirmed:  17
Tentative:  2
Rejected:  3
Iteration:  98 / 100
Confirmed:  17
Tentative:  2
Rejected:  3
Iteration:  99 / 100
Confirmed:  17
Tentative:  2
Rejected:  3


BorutaPy finished running.

Iteration:  100 / 100
Confirmed:  17
Tentative:  1
Rejected:  3
```

Out[69]:

```
BorutaPy(estimator=RandomForestClassifier(max_depth=5, n_estimators=123,
                                          random_state=RandomState(MT19937) at 0x7FEABE0
66B40),
         n_estimators='auto',
         random_state=RandomState(MT19937) at 0x7FEABE066B40, verbose=2)
```

In [70]:

```
print("Selected Features: ", boruta_selector.support_)     # check selected features


print("Ranking: ",boruta_selector.ranking_)                # check ranking of features
```

```
print("No. of significant features: ", boruta_selector.n_features_)
```

```
Selected Features:  [ True False  True  True  True  True False  True False False False  T
rue
  True  True  True  True  True  True  True  True  True  True]
Ranking:  [1 2 1 1 1 1 3 1 4 5 6 1 1 1 1 1 1 1 1 1 1]
No. of significant features:  17
```

In [71]:

```
selected_rfe_features = pd.DataFrame({'Feature':list(X_train.columns),
                                      'Ranking':boruta_selector.ranking_})
selected_rfe_features.sort_values(by='Ranking')
```

Out[71]:

	Feature	Ranking
0	Diagnosed_Condition	1
19	Patient_Smoker_YES	1
18	Patient_Smoker_NO	1
17	DX6	1
16	DX5	1
...	...	...
1	Patient_ID	2
6	C	3
8	E	4
9	F	5
10	Z	6

In [72]:

```
X_important_train = boruta_selector.transform(np.array(X_train))
X_important_test = boruta_selector.transform(np.array(X_test))
```

In [73]:

```
# Create a new random forest classifier for the most important features
rf_important = RandomForestClassifier(random_state=1, n_estimators=1000, n_jobs = -1)

# Train the new classifier on the new dataset containing the most important features
rf_important.fit(X_important_train, y_train)
```

Out[73]:

```
RandomForestClassifier(n_estimators=1000, n_jobs=-1, random_state=1)
```

In [74]:

```
y_important_pred = rf_important.predict(X_important_test)
rf_imp_fscore = f1_score(y_test, y_important_pred)
```

In [75]:

```
print(rf_imp_fscore)
```

```
0.8578215134034612
```

Hyper Parameter Tunning

In [76]:

```
from sklearn.model_selection import GridSearchCV
```

```
# Create the parameter grid based on the results of random search
param_grid = {
    'bootstrap': [True, False],
    'max_depth': [5, 10, 15],
    'n_estimators': [500, 1000]}
```

In [77]:

```
rf = RandomForestClassifier(random_state = 1)

# Grid search cv
grid_search = GridSearchCV(estimator = rf, param_grid = param_grid,
                           cv = 2, n_jobs = -1, verbose = 2)
```

In [78]:

```
grid_search.fit(X_important_train, y_train)
```

```
Fitting 2 folds for each of 12 candidates, totalling 24 fits
```

Out[78]:

```
GridSearchCV(cv=2, estimator=RandomForestClassifier(random_state=1), n_jobs=-1,
             param_grid={'bootstrap': [True, False], 'max_depth': [5, 10, 15],
                         'n_estimators': [500, 1000]},
             verbose=2)
```

In [79]:

```
grid_search.best_params_
```

Out[79]:

```
{'bootstrap': True, 'max_depth': 15, 'n_estimators': 500}
```

In [80]:

```
pred = grid_search.predict(X_important_test)
```

In [81]:

```
f1_score(y_test, pred)
```

Out[81]:

```
0.8657267539442766
```

Test Data

In [83]:

```
test_new_data = pd.read_csv("https://raw.githubusercontent.com/dphi-official/Datasets/master/pharma_data/Testing_set_begs.csv")
```

```
[CV] END .....bootstrap=True, max_depth=10, n_estimators=500; total time=   7.3s
[CV] END ....bootstrap=True, max_depth=15, n_estimators=1000; total time=  17.8s
[CV] END .....bootstrap=True, max_depth=10, n_estimators=500; total time=   7.2s
[CV] END ....bootstrap=True, max_depth=15, n_estimators=1000; total time=  17.9s
```

In [84]:

```
test_new_data.head()
```

Out[84]:

	ID_Patient_Care_Situation	Diagnosed_Condition	Patient_ID	Treated_with_drugs	Patient_Age	Patient_Body_Mass_Index	Pat
0	19150	40	3709	DX3	16	29.443894	
1	23216	52	986	DX6	24	26.836321	

	ID_Patient_Care_Situation	Diagnosed_Condition	Patient_ID	Treated_with_drugs	Patient_Age	Patient_Body_Mass_Index	Pat
2	11890	50	11821	DX4 DX5	63	25.523280	
3	7149	32	3292	DX6	42	27.171155	
4	22845	20	9959	DX3	50	25.556192	

```
[CV] END .....bootstrap=True, max_depth=5, n_estimators=1000; total time=   9.7s
[CV] END .....bootstrap=False, max_depth=5, n_estimators=500; total time=   5.4s
[CV] END ...bootstrap=False, max_depth=10, n_estimators=1000; total time=  16.0s
[CV] END .....bootstrap=True, max_depth=5, n_estimators=1000; total time=   9.7s
[CV] END .....bootstrap=False, max_depth=5, n_estimators=500; total time=   5.4s
[CV] END ...bootstrap=False, max_depth=10, n_estimators=1000; total time=  16.1s
[CV] END ....bootstrap=True, max_depth=10, n_estimators=1000; total time=  14.5s
[CV] END ....bootstrap=False, max_depth=10, n_estimators=500; total time=   8.6s
[CV] END ....bootstrap=False, max_depth=15, n_estimators=500; total time=   9.4s
[CV] END ....bootstrap=True, max_depth=10, n_estimators=1000; total time=  14.5s
[CV] END ....bootstrap=False, max_depth=10, n_estimators=500; total time=   8.6s
[CV] END ....bootstrap=False, max_depth=15, n_estimators=500; total time=   9.5s
[CV] END ......bootstrap=True, max_depth=5, n_estimators=500; total time=   4.9s
[CV] END .....bootstrap=True, max_depth=15, n_estimators=500; total time=   9.0s
[CV] END ....bootstrap=False, max_depth=5, n_estimators=1000; total time=  10.8s
[CV] END ...bootstrap=False, max_depth=15, n_estimators=1000; total time=  16.5s
[CV] END ......bootstrap=True, max_depth=5, n_estimators=500; total time=   4.9s
[CV] END .....bootstrap=True, max_depth=15, n_estimators=500; total time=   9.0s
[CV] END ....bootstrap=False, max_depth=5, n_estimators=1000; total time=  10.7s
[CV] END ...bootstrap=False, max_depth=15, n_estimators=1000; total time=  16.6s
```

In [86]:

```
test_new_data.Treated_with_drugs.value_counts()
```

Out[86]:

```
DX6                    3462
DX4                     785
DX5                     782
DX1                     753
DX3                     747
DX2                     745
DX2 DX4                 181
DX2 DX3                 179
DX1 DX5                 166
DX2 DX5                 165
DX3 DX5                 161
DX1 DX2                 160
DX4 DX5                 157
DX1 DX4                 153
DX1 DX3                 152
DX3 DX4                 148
DX1 DX3 DX4              41
DX1 DX2 DX5              41
DX2 DX3 DX4              40
DX1 DX2 DX3              40
DX3 DX4 DX5              40
DX1 DX2 DX4              38
DX2 DX3 DX5              37
DX1 DX4 DX5              34
DX2 DX4 DX5              33
DX1 DX3 DX5              23
DX1 DX3 DX4 DX5          11
DX2 DX3 DX4 DX5           8
DX1 DX2 DX4 DX5           8
DX1 DX2 DX3 DX5           6
DX1 DX2 DX3 DX4           5
DX1 DX2 DX3 DX4 DX5       2
Name: Treated_with_drugs, dtype: int64
```

In [87]:

```
test_new_data['Treated_with_drugs'] = test_new_data['Treated_with_drugs'].str.upper()
```

In [88]:

```
test_new_data.Patient_Smoker.value_counts()
```

Out[88]:

```
NO     5333
YES    3970
Name: Patient_Smoker, dtype: int64
```

In [90]:

```
def smoker(r):
  if (r == "NO") or (r == "NO "):
    return 'NO'
  elif (r == "YES") or (r == "YES ") or (r == "YESS") or (r == "YESS "):
    return 'YES'
  else:
    return 'Cannot say'

test_new_data.Patient_Smoker = test_new_data.Patient_Smoker.apply(smoker)
```

In [91]:

```
test_new_data.Patient_Rural_Urban.value_counts()
```

Out[91]:

```
RURAL    6502
URBAN    2801
Name: Patient_Rural_Urban, dtype: int64
```

In [92]:

```
test_new_data.Patient_mental_condition.value_counts()
```

Out[92]:

```
Stable    9303
Name: Patient_mental_condition, dtype: int64
```

In [93]:

```
test_new_data.isnull().sum()
```

Out[93]:

```
ID_Patient_Care_Situation    0
Diagnosed_Condition          0
Patient_ID                   0
Treated_with_drugs           0
Patient_Age                  0
Patient_Body_Mass_Index      0
Patient_Smoker               0
Patient_Rural_Urban          0
Patient_mental_condition     0
A                            0
B                            0
C                            0
D                            0
E                            0
F                            0
Z                            0
Number_of_prev_cond          0
dtype: int64
```

In [94]:

```
drugs = test_new_data['Treated_with_drugs'].str.get_dummies(sep=' ') # split all the entr
ies
drugs.head()
```

Out[94]:

	DX1	DX2	DX3	DX4	DX5	DX6
0	0	0	1	0	0	0
1	0	0	0	0	0	1
2	0	0	0	1	1	0
3	0	0	0	0	0	1
4	0	0	1	0	0	0

In [95]:

```
test_new_data = pd.concat([test_new_data, drugs], axis=1)      # concat the two dataframe
s 'drugs' and 'data'
test_new_data = test_new_data.drop('Treated_with_drugs', axis=1)     # dropping the column
'Treated_with_drugs' as its values are splitted into different columns

test_new_data.head()
```

Out[95]:

	ID_Patient_Care_Situation	Diagnosed_Condition	Patient_ID	Patient_Age	Patient_Body_Mass_Index	Patient_Smoker	Patient
0	19150	40	3709	16	29.443894	NO	
1	23216	52	986	24	26.836321	NO	
2	11890	50	11821	63	25.523280	NO	
3	7149	32	3292	42	27.171155	NO	
4	22845	20	9959	50	25.556192	NO	

In [96]:

```
test_new_data.Patient_Smoker.value_counts()
```

Out[96]:

```
NO     5333
YES    3970
Name: Patient_Smoker, dtype: int64
```

In [97]:

```
test_new_data.drop('Patient_mental_condition', axis = 1, inplace=True)
```

In [98]:

```
test_new_data = pd.get_dummies(test_new_data, columns=['Patient_Smoker', 'Patient_Rural_
Urban'])
```

In [99]:

```
test_new_data.head()
```

Out[99]:

	ID_Patient_Care_Situation	Diagnosed_Condition	Patient_ID	Patient_Age	Patient_Body_Mass_Index	A	B	C	D	E	..
0	19150	40	3709	16	29.443894	1.0	0.0	0.0	0.0	1.0	..
1	23216	52	986	24	26.836321	1.0	1.0	0.0	0.0	0.0	..
2	11890	50	11821	63	25.523280	1.0	0.0	0.0	0.0	1.0	..
3	7149	32	3292	42	27.171155	1.0	0.0	1.0	0.0	1.0	..
4	22845	20	9959	50	25.556192	1.0	0.0	0.0	0.0	0.0	..

In [100]:

```
test_new_data.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 9303 entries, 0 to 9302
Data columns (total 23 columns):
 #   Column                      Non-Null Count  Dtype  
---  ------                      --------------  -----  
 0   ID_Patient_Care_Situation   9303 non-null   int64  
 1   Diagnosed_Condition         9303 non-null   int64  
 2   Patient_ID                  9303 non-null   int64  
 3   Patient_Age                 9303 non-null   int64  
 4   Patient_Body_Mass_Index     9303 non-null   float64
 5   A                           9303 non-null   float64
 6   B                           9303 non-null   float64
 7   C                           9303 non-null   float64
 8   D                           9303 non-null   float64
 9   E                           9303 non-null   float64
 10  F                           9303 non-null   float64
 11  Z                           9303 non-null   float64
 12  Number_of_prev_cond         9303 non-null   float64
 13  DX1                         9303 non-null   int64  
 14  DX2                         9303 non-null   int64  
 15  DX3                         9303 non-null   int64  
 16  DX4                         9303 non-null   int64  
 17  DX5                         9303 non-null   int64  
 18  DX6                         9303 non-null   int64  
 19  Patient_Smoker_NO           9303 non-null   uint8  
 20  Patient_Smoker_YES          9303 non-null   uint8  
 21  Patient_Rural_Urban_RURAL   9303 non-null   uint8  
 22  Patient_Rural_Urban_URBAN   9303 non-null   uint8  
dtypes: float64(9), int64(10), uint8(4)
memory usage: 1.4 MB
```

In [101]:

```
test_new_data.drop(['ID_Patient_Care_Situation'], axis =1, inplace=True)
```

In [102]:

```
test_new_data.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 9303 entries, 0 to 9302
Data columns (total 22 columns):
 #   Column                      Non-Null Count  Dtype  
---  ------                      --------------  -----  
 0   Diagnosed_Condition         9303 non-null   int64  
 1   Patient_ID                  9303 non-null   int64  
 2   Patient_Age                 9303 non-null   int64  
 3   Patient_Body_Mass_Index     9303 non-null   float64
 4   A                           9303 non-null   float64
 5   B                           9303 non-null   float64
 6   C                           9303 non-null   float64
 7   D                           9303 non-null   float64
 8   E                           9303 non-null   float64
 9   F                           9303 non-null   float64
 10  Z                           9303 non-null   float64
 11  Number_of_prev_cond         9303 non-null   float64
 12  DX1                         9303 non-null   int64  
 13  DX2                         9303 non-null   int64  
 14  DX3                         9303 non-null   int64  
 15  DX4                         9303 non-null   int64  
 16  DX5                         9303 non-null   int64  
 17  DX6                         9303 non-null   int64  
 18  Patient_Smoker_NO           9303 non-null   uint8  
 19  Patient_Smoker_YES          9303 non-null   uint8  
 20  Patient_Rural_Urban_RURAL   9303 non-null   uint8  
 21  Patient_Rural_Urban_URBAN   9303 non-null   uint8  
dtypes: float64(9), int64(9), uint8(4)
memory usage: 1.3 MB
```

Prediction

In [103]:

```
imp_test_features = boruta_selector.transform(np.array(test_new_data))
```

In [104]:

```
prediction = grid_search.predict(imp_test_features)
```

In [ ]:

```
res = pd.DataFrame(prediction)
res.index = test_new_data.index
res.columns = ["prediction"]

res.to_csv('prediction_results_HP.csv')
files.download('prediction_results_HP.csv')
```