Classification: Persistent vs Non-Persistent

In [1]:

```
##Import Libraries
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns
%matplotlib inline

from sklearn.model_selection import train_test_split
from sklearn.preprocessing import StandardScaler
from sklearn.svm import SVC
from sklearn.metrics import accuracy_score,classification_report

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

In [2]:

```
#load data
data=pd.read_csv(r"C:\Users\DD\Desktop\Persistent_vs_NonPersistent\Persistent_vs_NonPersistent.csv")
```

In [3]:
```
data
```

Out[3]:

	Ptid	Persistency_Flag	Gender	Race	Ethnicity	Region	Age_Bucket	Ntm_Speciality	Ntm_Specialist_Flag	Nt
0	P1	Persistent	Male	Caucasian	Not Hispanic	West	>75	GENERAL PRACTITIONER	Others	OB/GYN
1	P2	Non-Persistent	Male	Asian	Not Hispanic	West	55-65	GENERAL PRACTITIONER	Others	OB/GYN
2	P3	Non-Persistent	Female	Other/Unknown	Hispanic	Midwest	65-75	GENERAL PRACTITIONER	Others	OB/GYN
3	P4	Non-Persistent	Female	Caucasian	Not Hispanic	Midwest	>75	GENERAL PRACTITIONER	Others	OB/GYN
4	P5	Non-Persistent	Female	Caucasian	Not Hispanic	Midwest	>75	GENERAL PRACTITIONER	Others	OB/GYN
...	...	...	...	...	...	...	...	...	...	
3419	P3420	Persistent	Female	Caucasian	Not Hispanic	South	>75	GENERAL PRACTITIONER	Others	OB/GYN
3420	P3421	Persistent	Female	Caucasian	Not Hispanic	South	>75	Unknown	Others	OB/GYN
3421	P3422	Persistent	Female	Caucasian	Not Hispanic	South	>75	ENDOCRINOLOGY	Specialist	
3422	P3423	Non-Persistent	Female	Caucasian	Not Hispanic	South	55-65	Unknown	Others	OB/GYN
3423	P3424	Non-Persistent	Female	Caucasian	Not Hispanic	South	65-75	Unknown	Others	OB/GYN

3424 rows × 69 columns

In [4]:
```
data.head()
```

Out[4]:

	Ptid	Persistency_Flag	Gender	Race	Ethnicity	Region	Age_Bucket	Ntm_Speciality	Ntm_Specialist_Flag	Ntm_Speci
0	P1	Persistent	Male	Caucasian	Not Hispanic	West	>75	GENERAL PRACTITIONER	Others	OB/GYN/Others/F
1	P2	Non-Persistent	Male	Asian	Not Hispanic	West	55-65	GENERAL PRACTITIONER	Others	OB/GYN/Others/F
2	P3	Non-Persistent	Female	Other/Unknown	Hispanic	Midwest	65-75	GENERAL PRACTITIONER	Others	OB/GYN/Others/F
3	P4	Non-Persistent	Female	Caucasian	Not Hispanic	Midwest	>75	GENERAL PRACTITIONER	Others	OB/GYN/Others/F
4	P5	Non-Persistent	Female	Caucasian	Not Hispanic	Midwest	>75	GENERAL PRACTITIONER	Others	OB/GYN/Others/F

5 rows × 69 columns

In [5]:
```
data.tail(3)
```

Out[5]:

	Ptid	Persistency_Flag	Gender	Race	Ethnicity	Region	Age_Bucket	Ntm_Speciality	Ntm_Specialist_Flag	Ntm_S
3421	P3422	Persistent	Female	Caucasian	Not Hispanic	South	>75	ENDOCRINOLOGY	Specialist	
3422	P3423	Non-Persistent	Female	Caucasian	Not Hispanic	South	55-65	Unknown	Others	OB/GYN/Othe
3423	P3424	Non-Persistent	Female	Caucasian	Not Hispanic	South	65-75	Unknown	Others	OB/GYN/Othe

3 rows × 69 columns

```
In [6]: data.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 3424 entries, 0 to 3423
Data columns (total 69 columns):
 #   Column                                                              Non-Null Count  Dtype  
---  ------                                                              --------------  -----  
 0   Ptid                                                                3424 non-null   object 
 1   Persistency_Flag                                                    3424 non-null   object 
 2   Gender                                                              3424 non-null   object 
 3   Race                                                                3424 non-null   object 
 4   Ethnicity                                                           3424 non-null   object 
 5   Region                                                              3424 non-null   object 
 6   Age_Bucket                                                          3424 non-null   object 
 7   Ntm_Speciality                                                      3424 non-null   object 
 8   Ntm_Specialist_Flag                                                 3424 non-null   object 
 9   Ntm_Speciality_Bucket                                               3424 non-null   object 
 10  Gluco_Record_Prior_Ntm                                              3424 non-null   object 
 11  Gluco_Record_During_Rx                                              3424 non-null   object 
 12  Dexa_Freq_During_Rx                                                 3309 non-null   float64
 13  Dexa_During_Rx                                                      3424 non-null   object 
 14  Frag_Frac_Prior_Ntm                                                 3424 non-null   object 
 15  Frag_Frac_During_Rx                                                 3424 non-null   object 
 16  Risk_Segment_Prior_Ntm                                              3424 non-null   object 
 17  Tscore_Bucket_Prior_Ntm                                             3424 non-null   object 
 18  Risk_Segment_During_Rx                                              3424 non-null   object 
 19  Tscore_Bucket_During_Rx                                             3424 non-null   object 
 20  Change_T_Score                                                      3424 non-null   object 
 21  Change_Risk_Segment                                                 3424 non-null   object 
 22  Adherent_Flag                                                       3424 non-null   object 
 23  Idn_Indicator                                                       3424 non-null   object 
 24  Injectable_Experience_During_Rx                                     3424 non-null   object 
 25  Comorb_Encounter_For_Screening_For_Malignant_Neoplasms              3424 non-null   object 
 26  Comorb_Encounter_For_Immunization                                   3424 non-null   object 
 27  Comorb_Encntr_For_General_Exam_W_O_Complaint,_Susp_Or_Reprtd_Dx     3424 non-null   object 
 28  Comorb_Vitamin_D_Deficiency                                         3424 non-null   object 
 29  Comorb_Other_Joint_Disorder_Not_Elsewhere_Classified                3424 non-null   object 
 30  Comorb_Encntr_For_Oth_Sp_Exam_W_O_Complaint_Suspected_Or_Reprtd_Dx  3424 non-null   object 
 31  Comorb_Long_Term_Current_Drug_Therapy                               3424 non-null   object 
 32  Comorb_Dorsalgia                                                    3424 non-null   object 
 33  Comorb_Personal_History_Of_Other_Diseases_And_Conditions            3424 non-null   object 
 34  Comorb_Other_Disorders_Of_Bone_Density_And_Structure                3424 non-null   object 
 35  Comorb_Disorders_of_lipoprotein_metabolism_and_other_lipidemias     3424 non-null   object 
 36  Comorb_Osteoporosis_without_current_pathological_fracture           3424 non-null   object 
 37  Comorb_Personal_history_of_malignant_neoplasm                       3424 non-null   object 
 38  Comorb_Gastro_esophageal_reflux_disease                             3424 non-null   object
 39  Concom_Cholesterol_And_Triglyceride_Regulating_Preparations         3424 non-null   object
 40  Concom_Narcotics                                                    3424 non-null   object
 41  Concom_Systemic_Corticosteroids_Plain                               3424 non-null   object
 42  Concom_Anti_Depressants_And_Mood_Stabilisers                        3424 non-null   object
 43  Concom_Fluoroquinolones                                             3424 non-null   object
 44  Concom_Cephalosporins                                               3424 non-null   object
 45  Concom_Macrolides_And_Similar_Types                                 3424 non-null   object
 46  Concom_Broad_Spectrum_Penicillins                                   3424 non-null   object
 47  Concom_Anaesthetics_General                                         3424 non-null   object
 48  Concom_Viral_Vaccines                                               3424 non-null   object
 49  Risk_Type_1_Insulin_Dependent_Diabetes                              3424 non-null   object
 50  Risk_Osteogenesis_Imperfecta                                        3424 non-null   object
 51  Risk_Rheumatoid_Arthritis                                           3276 non-null   object
 52  Risk_Untreated_Chronic_Hyperthyroidism                              3424 non-null   object
 53  Risk_Untreated_Chronic_Hypogonadism                                 3424 non-null   object
 54  Risk_Untreated_Early_Menopause                                      3424 non-null   object
 55  Risk_Patient_Parent_Fractured_Their_Hip                             3406 non-null   object
 56  Risk_Smoking_Tobacco                                                3424 non-null   object
 57  Risk_Chronic_Malnutrition_Or_Malabsorption                          3424 non-null   object
 58  Risk_Chronic_Liver_Disease                                          3424 non-null   object
 59  Risk_Family_History_Of_Osteoporosis                                 3424 non-null   object
 60  Risk_Low_Calcium_Intake                                             3424 non-null   object
 61  Risk_Vitamin_D_Insufficiency                                        3424 non-null   object
 62  Risk_Poor_Health_Frailty                                            3424 non-null   object
 63  Risk_Excessive_Thinness                                             3424 non-null   object
 64  Risk_Hysterectomy_Oophorectomy                                      3424 non-null   object
 65  Risk_Estrogen_Deficiency                                            3424 non-null   object
 66  Risk_Immobilization                                                 3424 non-null   object
 67  Risk_Recurring_Falls                                                3424 non-null   object
 68  Count_Of_Risks                                                      3424 non-null   int64
dtypes: float64(1), int64(1), object(67)
memory usage: 1.8+ MB
```

In [7]:

```
data.info
```

Out[7]:

```
<bound method DataFrame.info of        Ptid Persistency_Flag  Gender           Race     Ethnicity   Region  \
0        P1       Persistent    Male      Caucasian  Not Hispanic     West
1        P2   Non-Persistent    Male          Asian  Not Hispanic     West
2        P3   Non-Persistent  Female  Other/Unknown      Hispanic  Midwest
3        P4   Non-Persistent  Female      Caucasian  Not Hispanic  Midwest
4        P5   Non-Persistent  Female      Caucasian  Not Hispanic  Midwest
...     ...              ...     ...            ...           ...      ...
3419  P3420       Persistent  Female      Caucasian  Not Hispanic    South
3420  P3421       Persistent  Female      Caucasian  Not Hispanic    South
3421  P3422       Persistent  Female      Caucasian  Not Hispanic    South
3422  P3423   Non-Persistent  Female      Caucasian  Not Hispanic    South
3423  P3424   Non-Persistent  Female      Caucasian  Not Hispanic    South

     Age_Bucket        Ntm_Speciality Ntm_Specialist_Flag  \
0           >75  GENERAL PRACTITIONER              Others
1         55-65  GENERAL PRACTITIONER              Others
2         65-75  GENERAL PRACTITIONER              Others
3           >75  GENERAL PRACTITIONER              Others
4           >75  GENERAL PRACTITIONER              Others
...         ...                   ...                 ...
3419        >75  GENERAL PRACTITIONER              Others
3420        >75               Unknown              Others
3421        >75         ENDOCRINOLOGY          Specialist
3422      55-65               Unknown              Others
3423      65-75               Unknown              Others

          Ntm_Speciality_Bucket  ... Risk_Family_History_Of_Osteoporosis  \
0     OB/GYN/Others/PCP/Unknown  ...                                   N
1     OB/GYN/Others/PCP/Unknown  ...                                   N
2     OB/GYN/Others/PCP/Unknown  ...                                   N
3     OB/GYN/Others/PCP/Unknown  ...                                   N
4     OB/GYN/Others/PCP/Unknown  ...                                   N
...                         ...  ...                                 ...
3419  OB/GYN/Others/PCP/Unknown  ...                                   N
3420  OB/GYN/Others/PCP/Unknown  ...                                   N
3421               Endo/Onc/Uro  ...                                   N
3422  OB/GYN/Others/PCP/Unknown  ...                                   N
3423  OB/GYN/Others/PCP/Unknown  ...                                   N

     Risk_Low_Calcium_Intake  Risk_Vitamin_D_Insufficiency  \
0                          N                             N
1                          N                             N
```

```
2                          Y                             N
3                          N                             N
4                          N                             N
...                      ...                           ...
3419                       N                             Y
3420                       N                             N
3421                       N                             Y
3422                       N                             N
3423                       N                             Y

     Risk_Poor_Health_Frailty Risk_Excessive_Thinness  \
0                           N                       N
1                           N                       N
2                           N                       N
3                           N                       N
4                           N                       N
...                       ...                     ...
3419                        N                       N
3420                        N                       N
3421                        N                       N
3422                        N                       N
3423                        N                       N

     Risk_Hysterectomy_Oophorectomy Risk_Estrogen_Deficiency  \
0                                 N                        N
1                                 N                        N
2                                 N                        N
3                                 N                        N
4                                 N                        N
...                             ...                      ...
3419                              N                        N
3420                              N                        N
3421                              N                        N
3422                              N                        N
3423                              N                        N

     Risk_Immobilization Risk_Recurring_Falls Count_Of_Risks
0                      N                    N              0
1                      N                    N              0
2                      N                    N              2
3                      N                    N              1
4                      N                    N              1
...                  ...                  ...            ...
```

```
3419                    N                    N              1
3420                    N                    N              0
3421                    N                    N              1
3422                    N                    N              0
3423                    N                    N              1

[3424 rows x 69 columns]>
```

```
In [8]: data.describe(include="all")
```

Out[8]:

	Ptid	Persistency_Flag	Gender	Race	Ethnicity	Region	Age_Bucket	Ntm_Speciality	Ntm_Specialist_Flag	Ntm_Spe
count	3424	3424	3424	3424	3424	3424	3424	3424	3424	
unique	3424	2	2	4	3	5	4	36	2	
top	P1	Non-Persistent	Female	Caucasian	Not Hispanic	Midwest	>75	GENERAL PRACTITIONER	Others	OB/GYN/Others
freq	1	2135	3230	3148	3235	1383	1439	1535	2013	
mean	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	
std	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	
min	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	
25%	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	
50%	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	
75%	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	
max	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	

11 rows × 69 columns

In [9]:
```
data.isnull().sum()
```

Out[9]:
```
Ptid                             0
Persistency_Flag                 0
Gender                           0
Race                             0
Ethnicity                        0
                                ..
Risk_Hysterectomy_Oophorectomy   0
Risk_Estrogen_Deficiency         0
Risk_Immobilization              0
Risk_Recurring_Falls             0
Count_Of_Risks                   0
Length: 69, dtype: int64
```

In [10]:
```
#any null value present
data.isnull().values.any()
```

Out[10]:
```
True
```

In [11]:
```
data.isnull().sum()
```

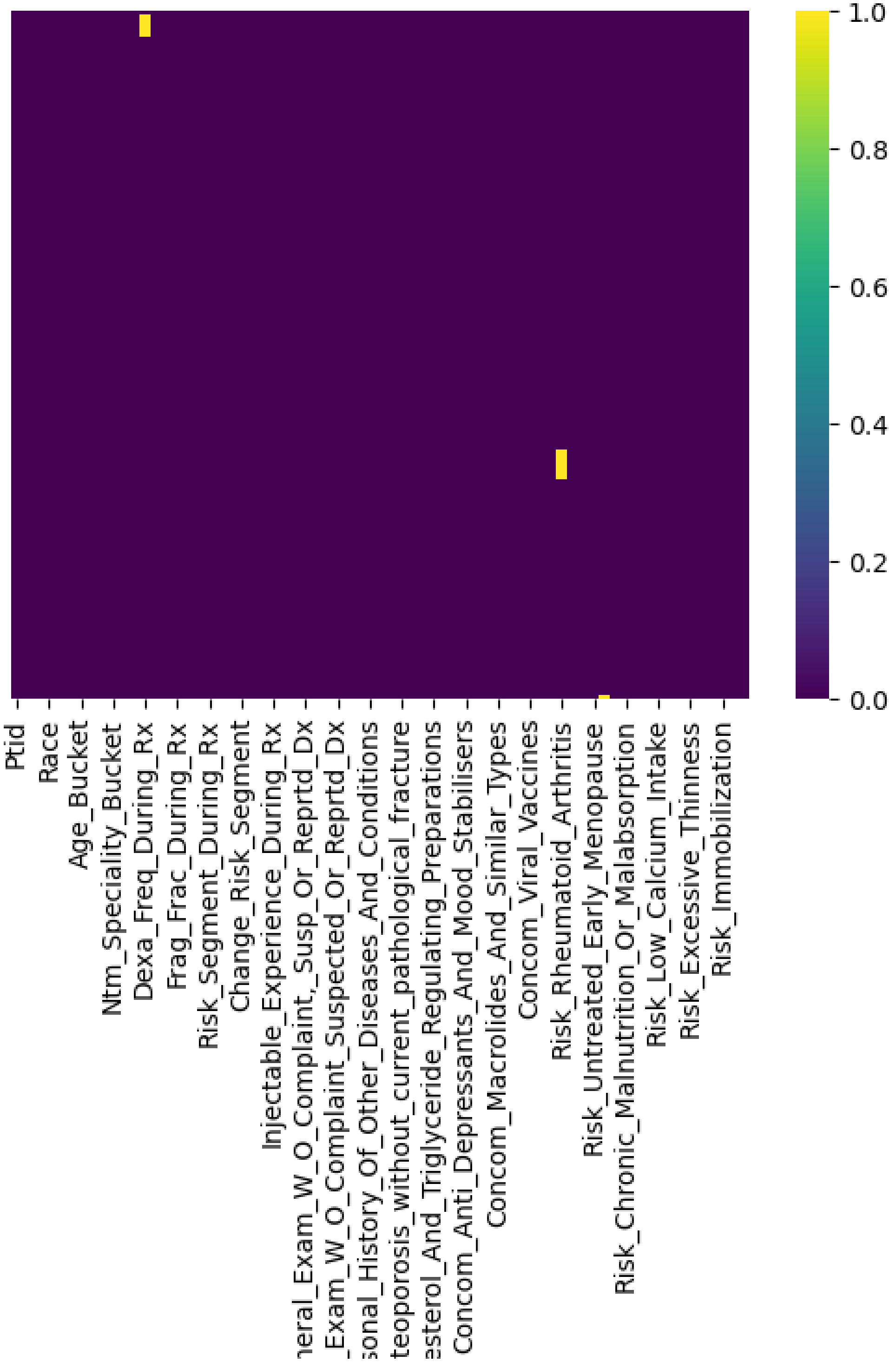
Out[11]:
```
Ptid                             0
Persistency_Flag                 0
Gender                           0
Race                             0
Ethnicity                        0
                                ..
Risk_Hysterectomy_Oophorectomy   0
Risk_Estrogen_Deficiency         0
Risk_Immobilization              0
Risk_Recurring_Falls             0
Count_Of_Risks                   0
Length: 69, dtype: int64
```

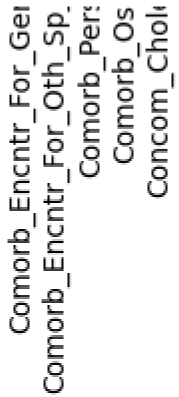
In [12]:

```
sns.heatmap(data.isnull(),yticklabels=False,cmap="viridis")
```

Out[12]:

```
<Axes: >
```


1.0
0.8
0.6
0.4
0.2
0.0
Ptid
Race
Age_Bucket
Ntm_Speciality_Bucket
Dexa_Freq_During_Rx
Frag_Frac_During_Rx
Risk_Segment_During_Rx
Change_Risk_Segment
Injectable_Experience_During_Rx
ıeral_Exam_W_O_Complaint,_Susp_Or_Reprtd_Dx
_Exam_W_O_Complaint_Suspected_Or_Reprtd_Dx
sonal_History_Of_Other_Diseases_And_Conditions
teoporosis_without_current_pathological_fracture
esterol_And_Triglyceride_Regulating_Preparations
Concom_Anti_Depressants_And_Mood_Stabilisers
Concom_Macrolides_And_Similar_Types
Concom_Viral_Vaccines
Risk_Rheumatoid_Arthritis
Risk_Untreated_Early_Menopause
Risk_Chronic_Malnutrition_Or_Malabsorption
Risk_Low_Calcium_Intake
Risk_Excessive_Thinness
Risk_Immobilization



Filling missing values

In [13]:

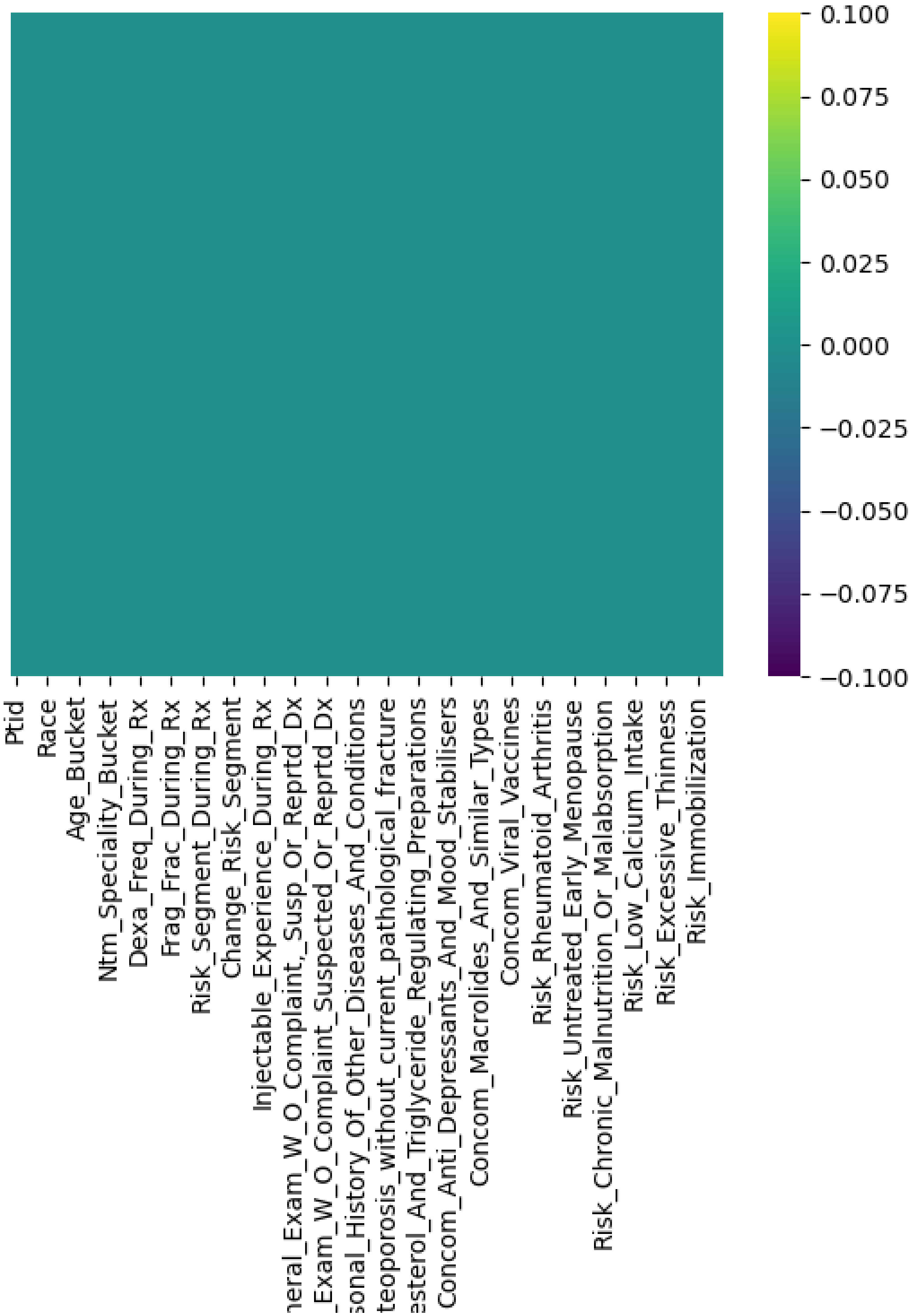
```
data["Dexa_Freq_During_Rx"].fillna(data["Dexa_Freq_During_Rx"].median(),inplace=True)


data["Risk_Rheumatoid_Arthritis"].fillna(data["Risk_Rheumatoid_Arthritis"].mode()[0],inplace=True)
data["Risk_Patient_Parent_Fractured_Their_Hip"].fillna(data["Risk_Patient_Parent_Fractured_Their_Hip"].mode()[
```

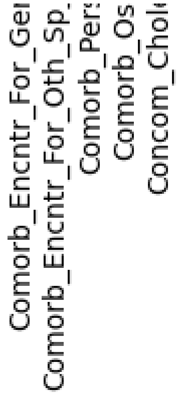
In [14]:

```
sns.heatmap(data.isnull(),yticklabels=False,cmap="viridis")
```

Out[14]:

```
<Axes: >
```


0.100
0.075
0.050
0.025
0.000
−0.025
−0.050
−0.075
−0.100
Ptid
Race
Age_Bucket
Ntm_Speciality_Bucket
Dexa_Freq_During_Rx
Frag_Frac_During_Rx
Risk_Segment_During_Rx
Change_Risk_Segment
Injectable_Experience_During_Rx
neral_Exam_W_O_Complaint,_Susp_Or_Reprtd_Dx
_Exam_W_O_Complaint_Suspected_Or_Reprtd_Dx
sonal_History_Of_Other_Diseases_And_Conditions
teoporosis_without_current_pathological_fracture
esterol_And_Triglyceride_Regulating_Preparations
Concom_Anti_Depressants_And_Mood_Stabilisers
Concom_Macrolides_And_Similar_Types
Concom_Viral_Vaccines
Risk_Rheumatoid_Arthritis
Risk_Untreated_Early_Menopause
Risk_Chronic_Malnutrition_Or_Malabsorption
Risk_Low_Calcium_Intake
Risk_Excessive_Thinness
Risk_Immobilization



In [15]:
```
cat_data=data.select_dtypes(include="object")
num_data=data.select_dtypes(exclude="object")
```

In [16]:

```
cat_data
```

Out[16]:

	Ptid	Persistency_Flag	Gender	Race	Ethnicity	Region	Age_Bucket	Ntm_Speciality	Ntm_Specialist_Flag	Nt
0	P1	Persistent	Male	Caucasian	Not Hispanic	West	>75	GENERAL PRACTITIONER	Others	OB/GYN
1	P2	Non-Persistent	Male	Asian	Not Hispanic	West	55-65	GENERAL PRACTITIONER	Others	OB/GYN
2	P3	Non-Persistent	Female	Other/Unknown	Hispanic	Midwest	65-75	GENERAL PRACTITIONER	Others	OB/GYN
3	P4	Non-Persistent	Female	Caucasian	Not Hispanic	Midwest	>75	GENERAL PRACTITIONER	Others	OB/GYN
4	P5	Non-Persistent	Female	Caucasian	Not Hispanic	Midwest	>75	GENERAL PRACTITIONER	Others	OB/GYN
...	...	...	...	...	...	...	...	...	...	
3419	P3420	Persistent	Female	Caucasian	Not Hispanic	South	>75	GENERAL PRACTITIONER	Others	OB/GYN
3420	P3421	Persistent	Female	Caucasian	Not Hispanic	South	>75	Unknown	Others	OB/GYN
3421	P3422	Persistent	Female	Caucasian	Not Hispanic	South	>75	ENDOCRINOLOGY	Specialist	
3422	P3423	Non-Persistent	Female	Caucasian	Not Hispanic	South	55-65	Unknown	Others	OB/GYN
3423	P3424	Non-Persistent	Female	Caucasian	Not Hispanic	South	65-75	Unknown	Others	OB/GYN

3424 rows × 67 columns

In [17]:

```
num_data
```

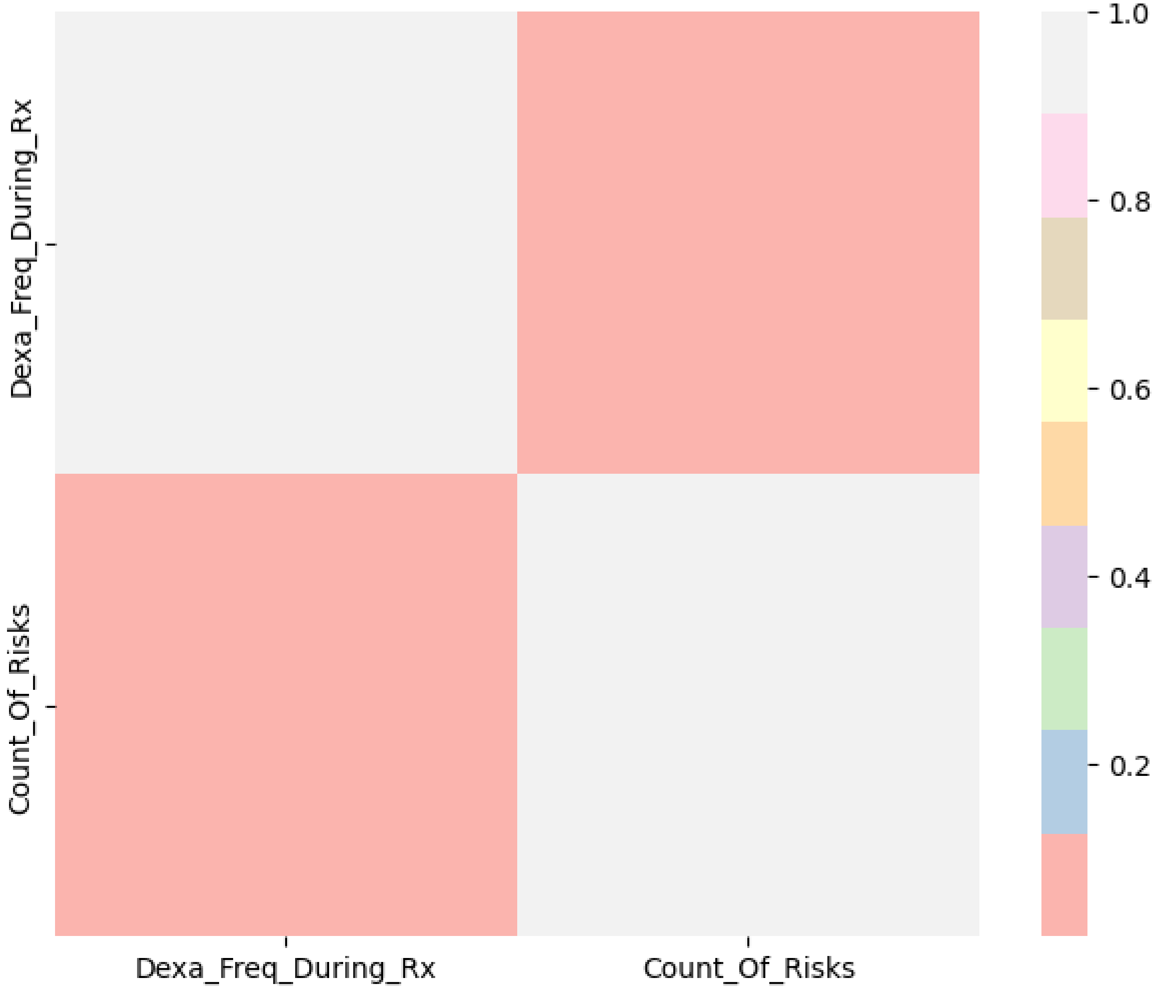
Out[17]:

	Dexa_Freq_During_Rx	Count_Of_Risks
0	0.0	0
1	0.0	0
2	0.0	2
3	0.0	1
4	0.0	1
...	...	...
3419	0.0	1
3420	0.0	0
3421	7.0	1
3422	0.0	0
3423	0.0	1

3424 rows × 2 columns

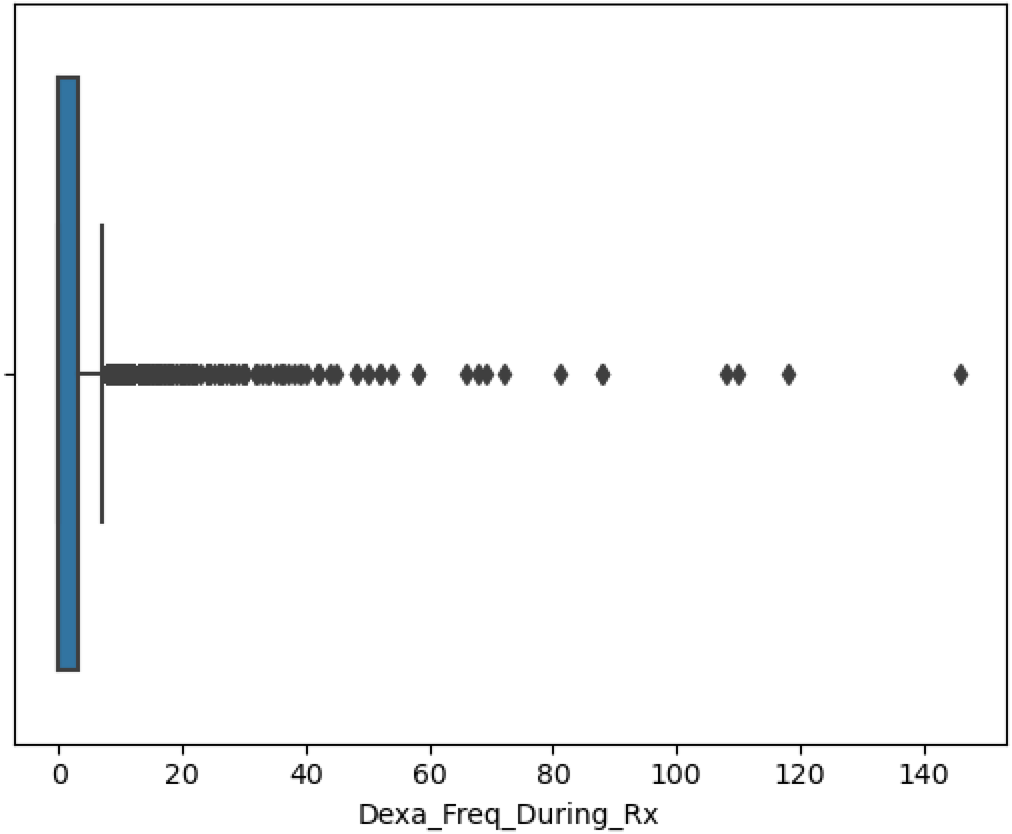
Data Visualization

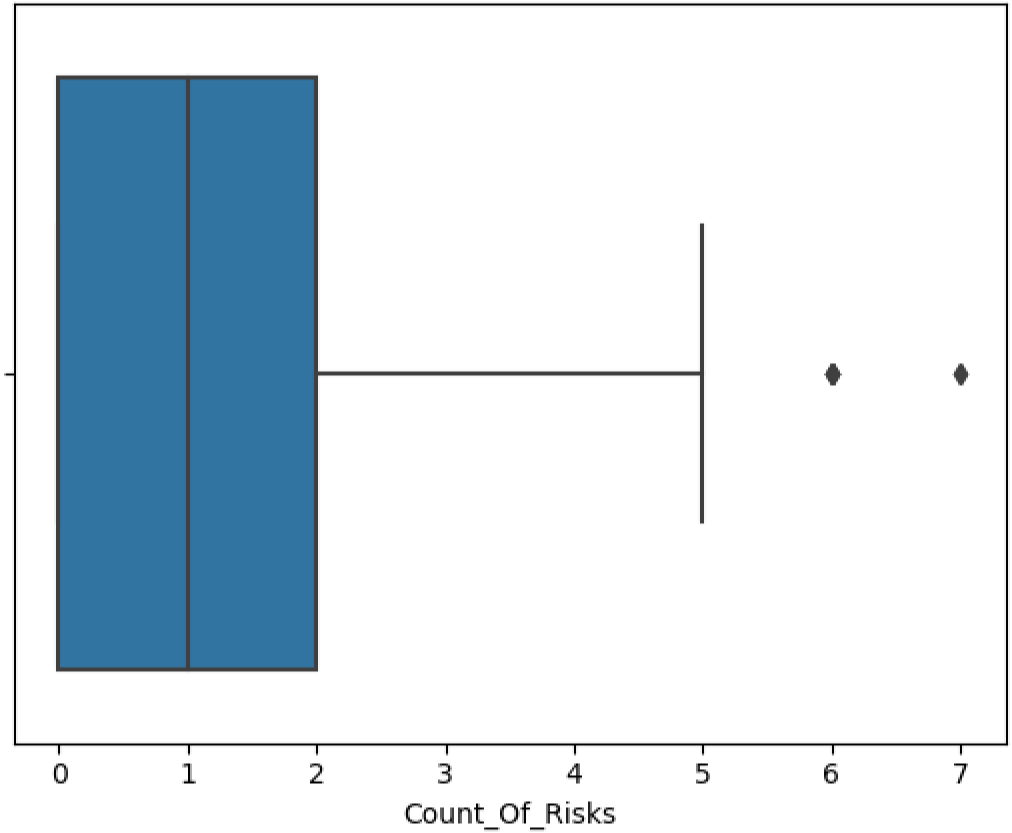
In [18]:
```
#Examaning a correlation matrix of all the features
corrmat=num_data.corr()
plt.figure(figsize=(8,6))
sns.heatmap(corrmat,cmap="Pastel1",square=True)
plt.show()
```



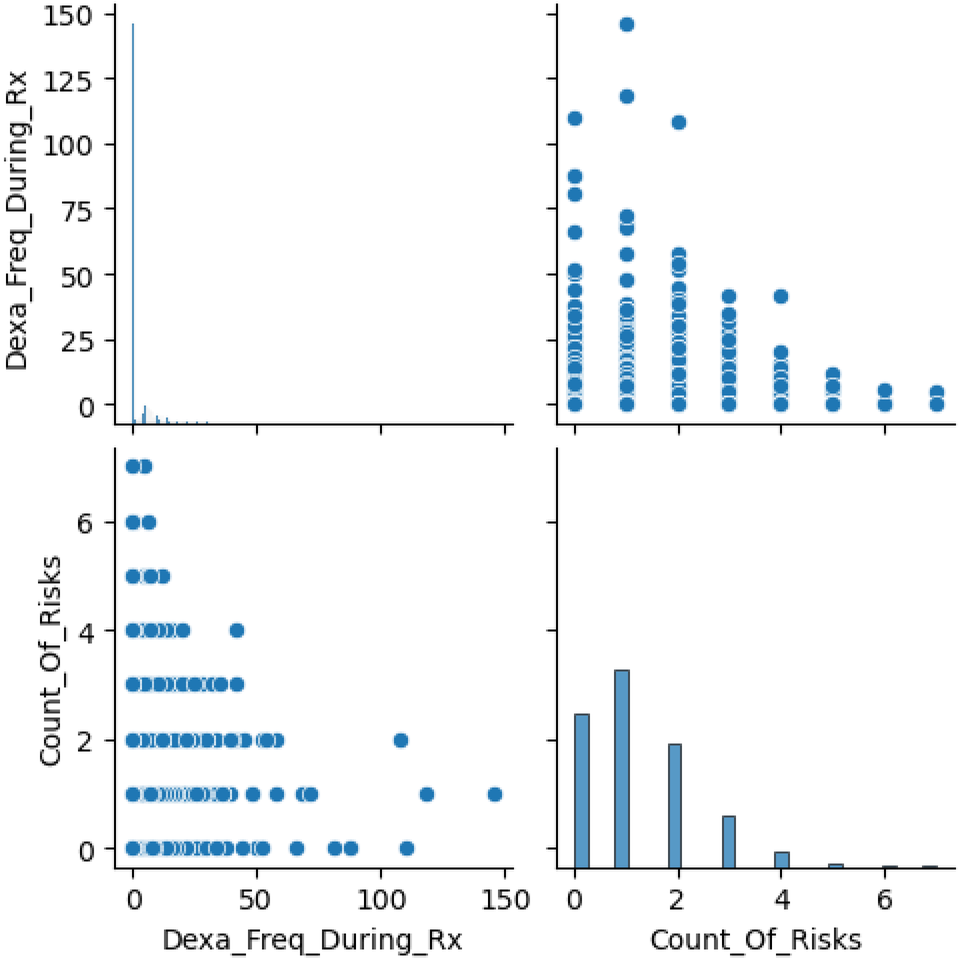
In [19]:

```
for i in num_data.columns:
    sns.boxplot(x=data[i])  # Use data instead of num_data here
    plt.show()
```



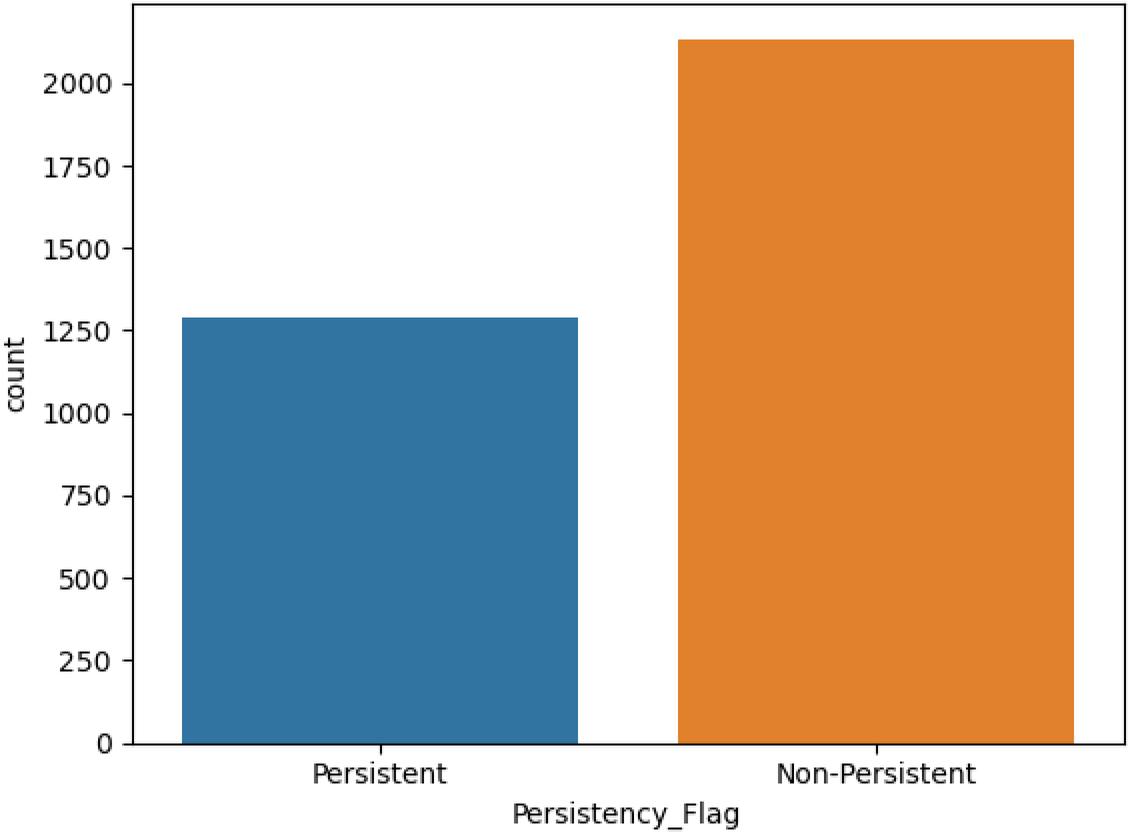

0
1
2
3
4
5
6
7
Count_Of_Risks

```
In [20]: sns.pairplot(data)

Out[20]: <seaborn.axisgrid.PairGrid at 0x23b2d065d50>
```

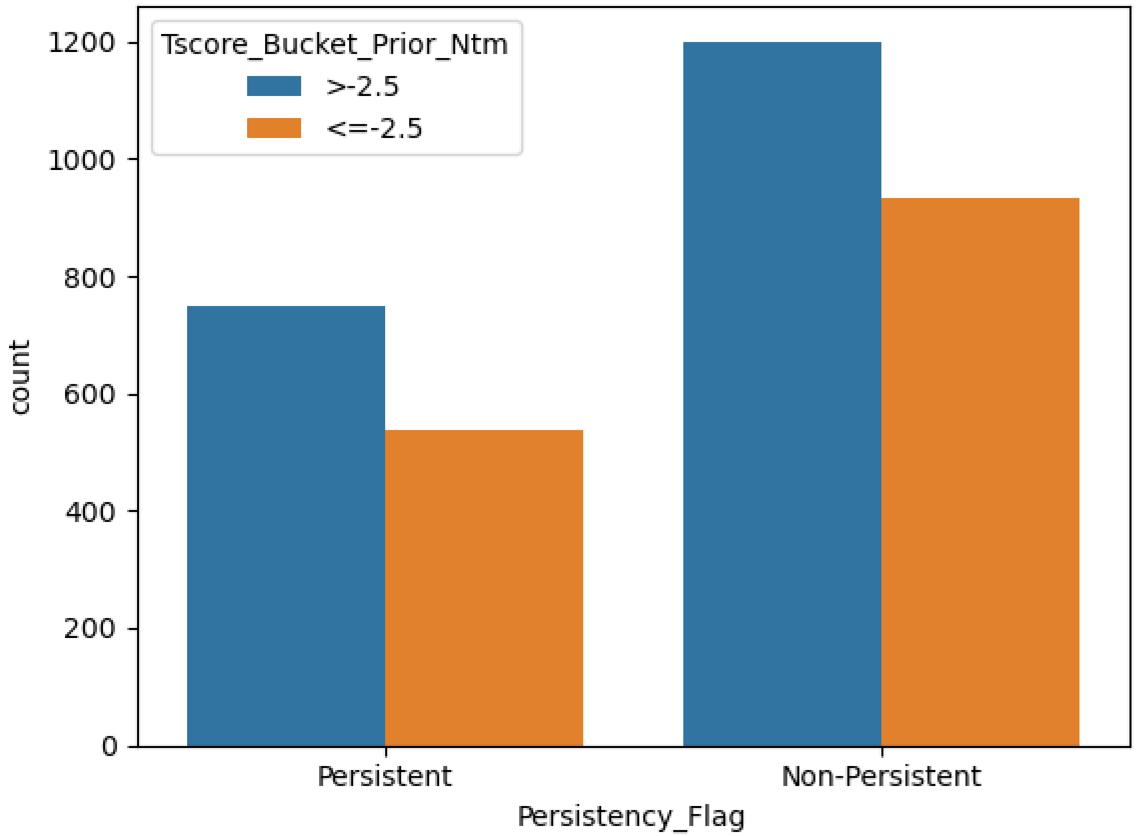


In [21]:
```
sns.countplot(x="Persistency_Flag",data=data)
```

Out[21]:
```
<Axes: xlabel='Persistency_Flag', ylabel='count'>
```

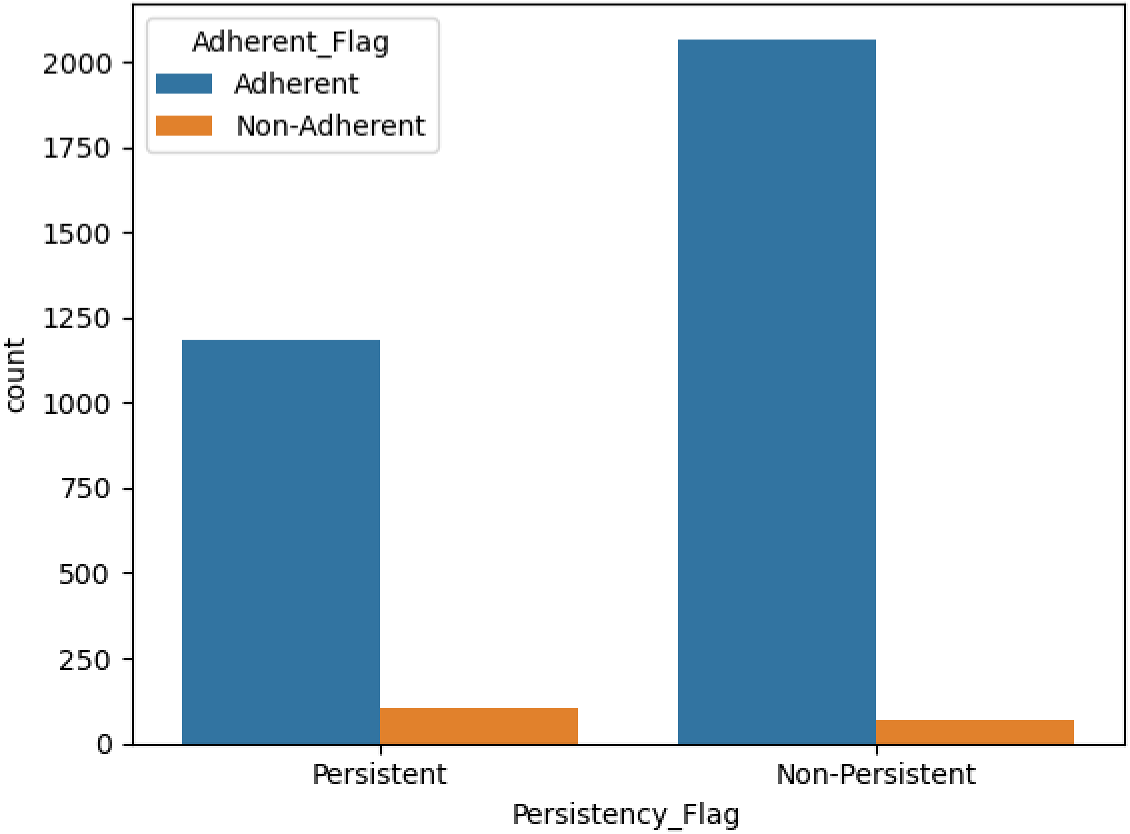


In [22]:
```
sns.countplot(x="Persistency_Flag",hue="Tscore_Bucket_Prior_Ntm",data=data)
plt.show()
```



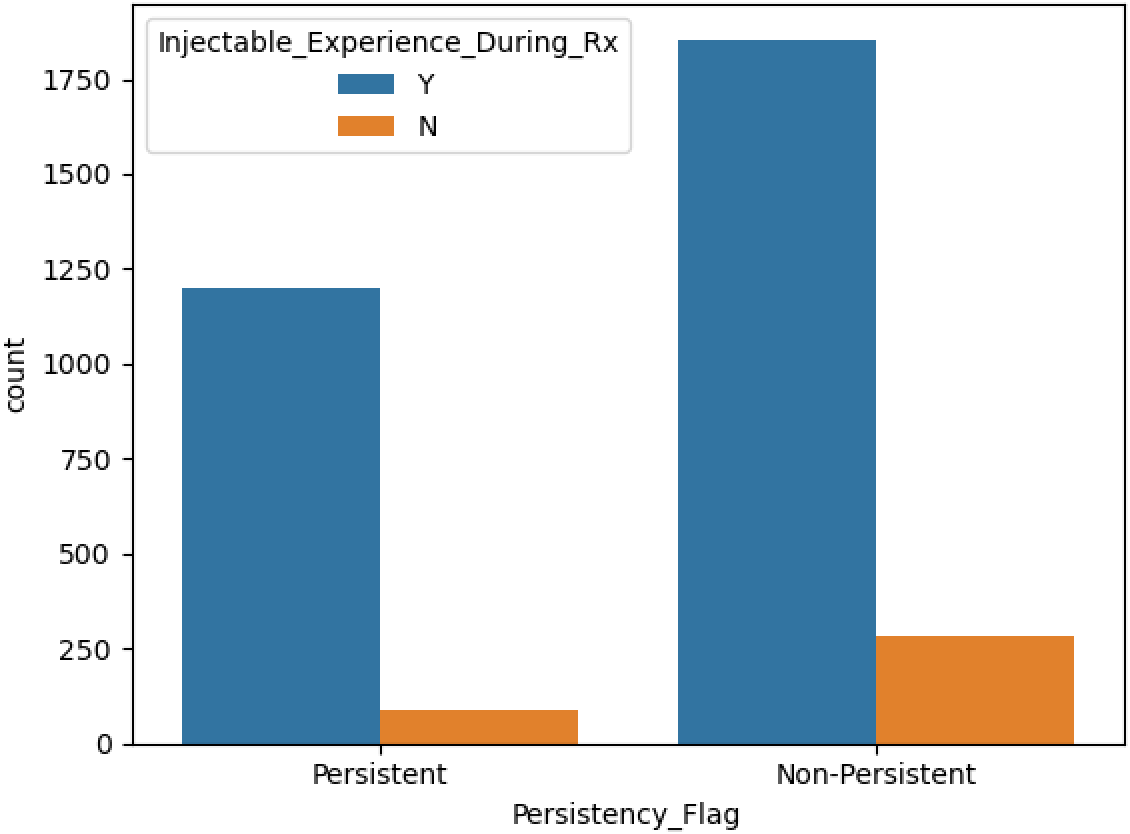
In [23]:

```
sns.countplot(x="Persistency_Flag",hue='Adherent_Flag', data=data)
plt.show()
```



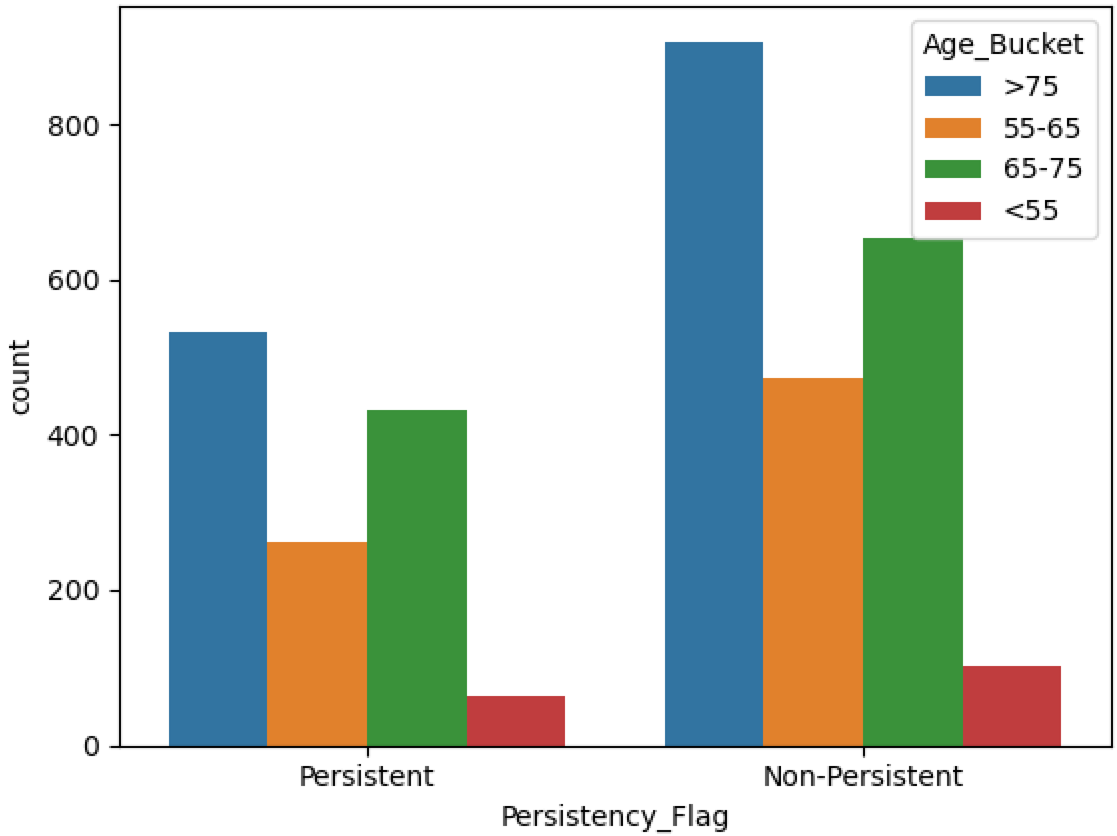
In [24]:

```
sns.countplot(x="Persistency_Flag",hue='Injectable_Experience_During_Rx', data=data)
plt.show()
```

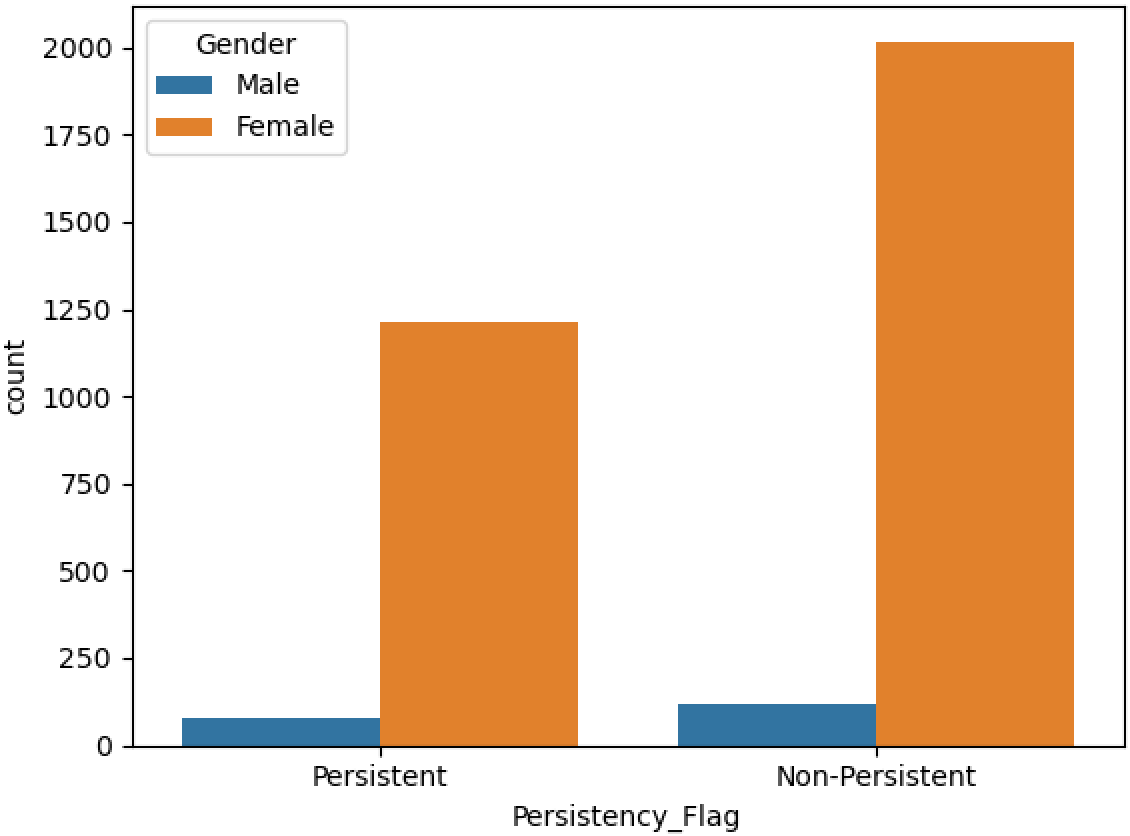


In [25]:

```
sns.countplot(x="Persistency_Flag", hue='Age_Bucket', data=data)
plt.show()
```

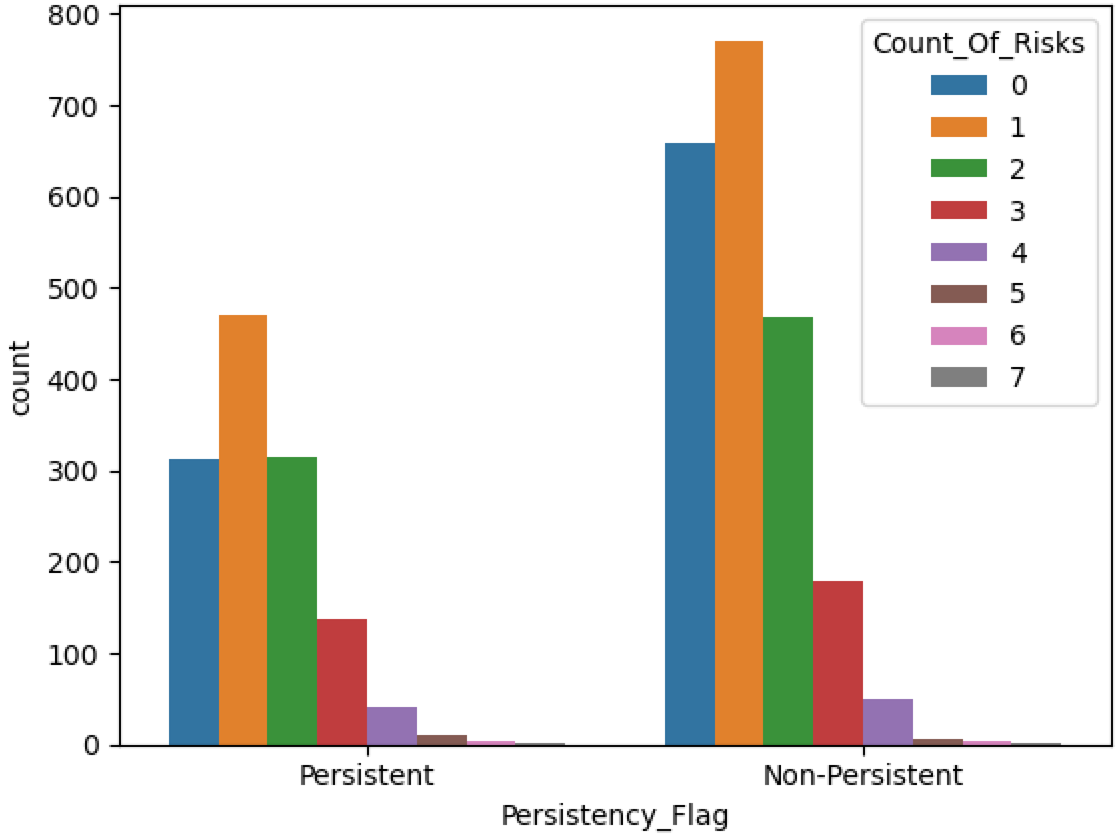


```
In [26]: sns.countplot(x="Persistency_Flag", hue='Gender', data=data)
         plt.show()
```

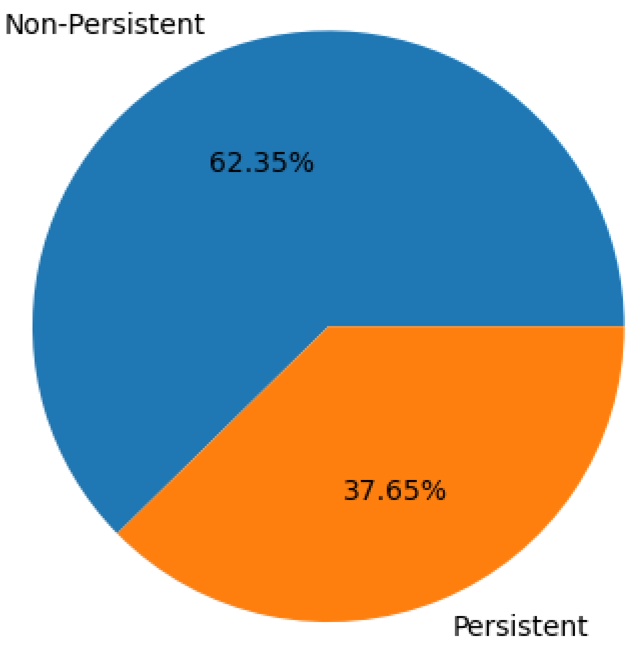


```
In [27]: sns.countplot(x="Persistency_Flag", hue='Count_Of_Risks', data=data)
```

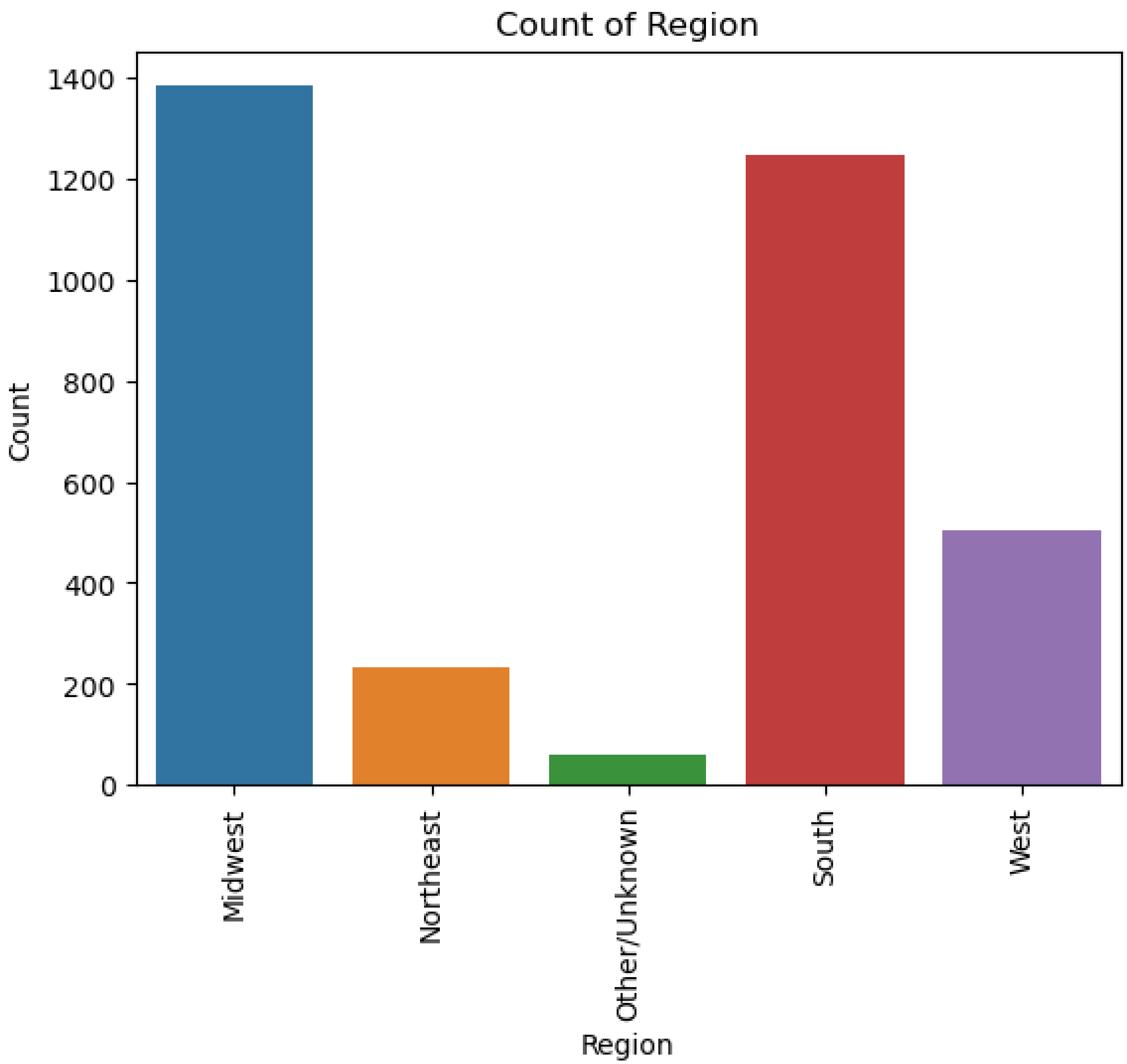
```
Out[27]: <Axes: xlabel='Persistency_Flag', ylabel='count'>
```



In [28]:
```
b=data.groupby("Persistency_Flag")["Persistency_Flag"].count()
plt.pie(b,labels=b.index,autopct="%.2f%%")
plt.show()
```

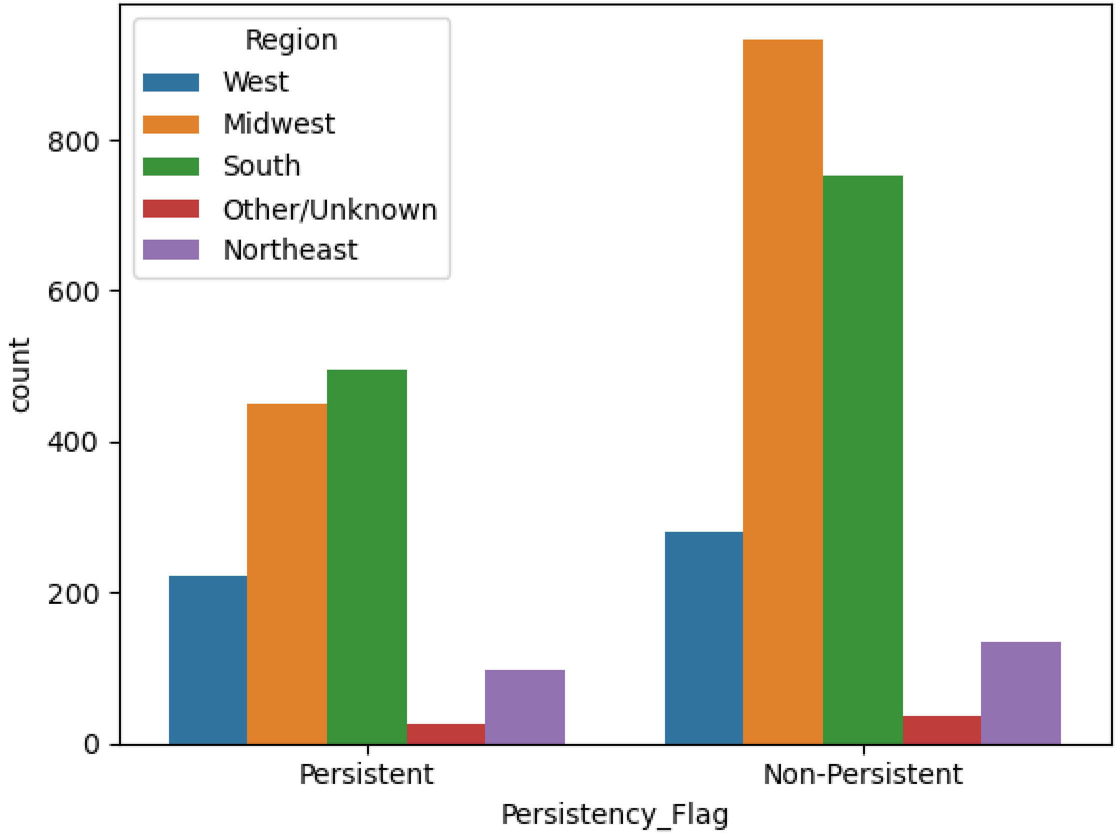


In [29]:
```
a=data.groupby("Region")["Region"].count()
sns.barplot(x=a.index,y=a.values)
plt.xticks(rotation=90)
plt.title("Count of Region")
plt.xlabel("Region")
plt.ylabel("Count")
plt.show()
```



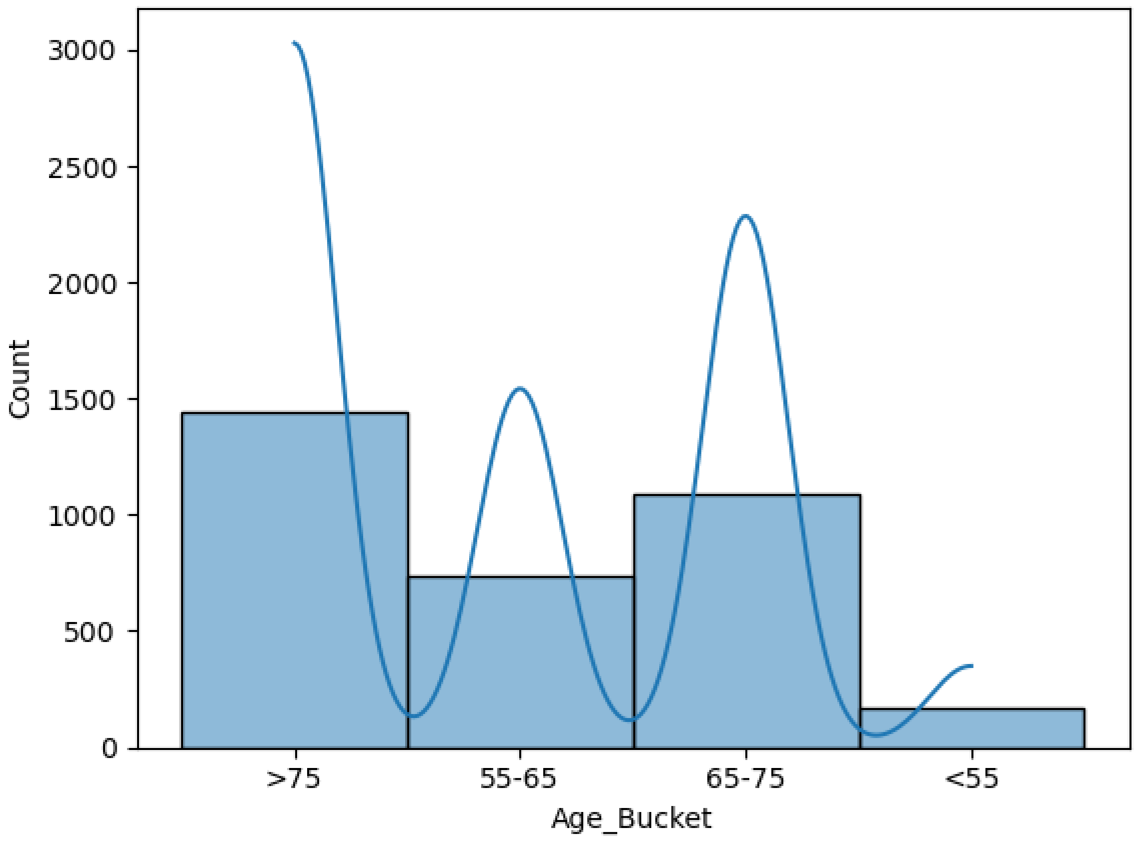
```
In [30]: sns.countplot(x="Persistency_Flag", hue='Region', data=data)
```

```
Out[30]: <Axes: xlabel='Persistency_Flag', ylabel='count'>
```



In [31]:
```
sns.histplot(data["Age_Bucket"],bins=10,kde=True)
```

Out[31]:
```
<Axes: xlabel='Age_Bucket', ylabel='Count'>
```



Outlier detection and removal

In [32]:
```
from scipy import stats
z_scores=stats.zscore(data["Dexa_Freq_During_Rx"])
z_score_outliers=(z_scores<-3)|(z_scores>3)
```

In [33]:
```
z_score_outlier_rows=data[z_score_outliers]
print("outliers detected by Z-score:",z_score_outlier_rows)
```

```
outliers detected by Z-score:        Ptid Persistency_Flag  Gender          Race     Ethnicity     Region  \
198    P199       Persistent  Female     Caucasian  Not Hispanic      South
241    P242       Persistent  Female     Caucasian  Not Hispanic    Midwest
541    P542       Persistent  Female     Caucasian  Not Hispanic    Midwest
651    P652       Persistent  Female     Caucasian  Not Hispanic    Midwest
1265  P1266       Persistent  Female     Caucasian  Not Hispanic       West
1360  P1361       Persistent  Female     Caucasian  Not Hispanic      South
1370  P1371   Non-Persistent  Female     Caucasian  Not Hispanic      South
1398  P1399       Persistent  Female         Asian  Not Hispanic      South
1734  P1735       Persistent    Male     Caucasian  Not Hispanic    Midwest
1838  P1839       Persistent  Female     Caucasian  Not Hispanic  Northeast
1854  P1855       Persistent    Male     Caucasian  Not Hispanic  Northeast
1901  P1902   Non-Persistent  Female     Caucasian  Not Hispanic    Midwest
1909  P1910       Persistent  Female     Caucasian  Not Hispanic    Midwest
1920  P1921       Persistent  Female Other/Unknown       Unknown    Midwest
1949  P1950       Persistent  Female     Caucasian  Not Hispanic    Midwest
1993  P1994       Persistent  Female     Caucasian  Not Hispanic      South
2006  P2007   Non-Persistent  Female     Caucasian  Not Hispanic      South
```

In [34]:
```
data.shape
```

Out[34]:
```
(3424, 69)
```

In [35]:
```
x=(z_scores>-3)&(z_scores<3)
```

In [36]:
```
new_data=data[x]   # create a new data frame
```

In [37]:

```
new_data
```

Out[37]:

	Ptid	Persistency_Flag	Gender	Race	Ethnicity	Region	Age_Bucket	Ntm_Speciality	Ntm_Specialist_Flag	Nt
0	P1	Persistent	Male	Caucasian	Not Hispanic	West	>75	GENERAL PRACTITIONER	Others	OB/GYN
1	P2	Non-Persistent	Male	Asian	Not Hispanic	West	55-65	GENERAL PRACTITIONER	Others	OB/GYN
2	P3	Non-Persistent	Female	Other/Unknown	Hispanic	Midwest	65-75	GENERAL PRACTITIONER	Others	OB/GYN
3	P4	Non-Persistent	Female	Caucasian	Not Hispanic	Midwest	>75	GENERAL PRACTITIONER	Others	OB/GYN
4	P5	Non-Persistent	Female	Caucasian	Not Hispanic	Midwest	>75	GENERAL PRACTITIONER	Others	OB/GYN
...	...	...	...	...	...	...	...	...	...	
3419	P3420	Persistent	Female	Caucasian	Not Hispanic	South	>75	GENERAL PRACTITIONER	Others	OB/GYN
3420	P3421	Persistent	Female	Caucasian	Not Hispanic	South	>75	Unknown	Others	OB/GYN
3421	P3422	Persistent	Female	Caucasian	Not Hispanic	South	>75	ENDOCRINOLOGY	Specialist	
3422	P3423	Non-Persistent	Female	Caucasian	Not Hispanic	South	55-65	Unknown	Others	OB/GYN
3423	P3424	Non-Persistent	Female	Caucasian	Not Hispanic	South	65-75	Unknown	Others	OB/GYN

3367 rows × 69 columns

In [38]:

```
z_scores=stats.zscore(new_data["Count_Of_Risks"])
z_score_outlier=(z_scores<-3)|(z_scores>3)
```

In [39]:

```
z_score_outlier_row=new_data[z_score_outlier]
print("outliers detected by Z-score:",z_score_outlier_row)
```

```
outliers detected by Z-score:        Ptid Persistency_Flag  Gender              Race     Ethnicity  \
302    P303       Persistent  Female          Caucasian  Not Hispanic
342    P343       Persistent  Female          Caucasian  Not Hispanic
352    P353       Persistent  Female          Caucasian  Not Hispanic
495    P496       Persistent  Female          Caucasian  Not Hispanic
557    P558       Persistent  Female          Caucasian  Not Hispanic
731    P732       Persistent  Female          Caucasian  Not Hispanic
741    P742       Persistent  Female          Caucasian  Not Hispanic
754    P755       Persistent  Female          Caucasian  Not Hispanic
787    P788   Non-Persistent  Female          Caucasian  Not Hispanic
817    P818       Persistent  Female   African American  Not Hispanic
1059  P1060   Non-Persistent  Female          Caucasian  Not Hispanic
1112  P1113       Persistent  Female          Caucasian  Not Hispanic
1247  P1248   Non-Persistent    Male          Caucasian  Not Hispanic
1759  P1760       Persistent  Female          Caucasian  Not Hispanic
1798  P1799   Non-Persistent  Female          Caucasian      Hispanic
2091  P2092   Non-Persistent  Female          Caucasian  Not Hispanic
2592  P2593   Non-Persistent  Female          Caucasian  Not Hispanic
2601  P2602   Non-Persistent  Female          Caucasian  Not Hispanic
2860  P2861   Non-Persistent    Male          Caucasian  Not Hispanic
```

In [40]:

```
p=(z_scores>-3)&(z_scores<3)
data_new=new_data[p]
```

In [41]:
```
data_new
```

Out[41]:

	Ptid	Persistency_Flag	Gender	Race	Ethnicity	Region	Age_Bucket	Ntm_Speciality	Ntm_Specialist_Flag	Nt
0	P1	Persistent	Male	Caucasian	Not Hispanic	West	>75	GENERAL PRACTITIONER	Others	OB/GYN
1	P2	Non-Persistent	Male	Asian	Not Hispanic	West	55-65	GENERAL PRACTITIONER	Others	OB/GYN
2	P3	Non-Persistent	Female	Other/Unknown	Hispanic	Midwest	65-75	GENERAL PRACTITIONER	Others	OB/GYN
3	P4	Non-Persistent	Female	Caucasian	Not Hispanic	Midwest	>75	GENERAL PRACTITIONER	Others	OB/GYN
4	P5	Non-Persistent	Female	Caucasian	Not Hispanic	Midwest	>75	GENERAL PRACTITIONER	Others	OB/GYN
...	...	...	...	...	...	...	...	...	...	
3419	P3420	Persistent	Female	Caucasian	Not Hispanic	South	>75	GENERAL PRACTITIONER	Others	OB/GYN
3420	P3421	Persistent	Female	Caucasian	Not Hispanic	South	>75	Unknown	Others	OB/GYN
3421	P3422	Persistent	Female	Caucasian	Not Hispanic	South	>75	ENDOCRINOLOGY	Specialist	
3422	P3423	Non-Persistent	Female	Caucasian	Not Hispanic	South	55-65	Unknown	Others	OB/GYN
3423	P3424	Non-Persistent	Female	Caucasian	Not Hispanic	South	65-75	Unknown	Others	OB/GYN

3344 rows × 69 columns

In [ ]:

In [42]:
```
from sklearn.preprocessing import OneHotEncoder,StandardScaler
categorical_cols=['Ptid', 'Gender', 'Race', 'Ethnicity', 'Region', 'Age_Bucket', 'Ntm_Speciality',
'Ntm_Specialist_Flag', 'Ntm_Speciality_Bucket', 'Gluco_Record_Prior_Ntm',
'Gluco_Record_During_Rx', 'Dexa_During_Rx', 'Frag_Frac_Prior_Ntm',
'Frag_Frac_During_Rx', 'Risk_Segment_Prior_Ntm', 'Tscore_Bucket_Prior_Ntm',
'Risk_Segment_During_Rx', 'Tscore_Bucket_During_Rx', 'Change_T_Score',
'Change_Risk_Segment', 'Adherent_Flag', 'Idn_Indicator',
'Injectable_Experience_During_Rx', 'Comorb_Encounter_For_Screening_For_Malignant_Neoplasms',
'Comorb_Encounter_For_Immunization','Comorb_Encntr_For_General_Exam_W_O_Complaint,_Susp_Or_Reprtd_Dx',  'Comor
'Comorb_Other_Joint_Disorder_Not_Elsewhere_Classified',
'Comorb_Encntr_For_Oth_Sp_Exam_W_O_Complaint_Suspected_Or_Reprtd_Dx',
'Comorb_Long_Term_Current_Drug_Therapy', 'Comorb_Dorsalgia',
'Comorb_Personal_History_Of_Other_Diseases_And_Conditions',
'Comorb_Other_Disorders_Of_Bone_Density_And_Structure',
'Comorb_Disorders_of_lipoprotein_metabolism_and_other_lipidemias',
'Comorb_Osteoporosis_without_current_pathological_fracture', 'Comorb_Personal_history_of_malignant_neoplasm',
'Comorb_Gastro_esophageal_reflux_disease', 'Concom_Cholesterol_And_Triglyceride_Regulating_Preparations',
'Concom_Narcotics', 'Concom_Systemic_Corticosteroids_Plain', 'Concom_Anti_Depressants_And_Mood_Stabilisers',
'Concom_Fluoroquinolones', 'Concom_Cephalosporins', 'Concom_Macrolides_And_Similar_Types',
'Concom_Broad_Spectrum_Penicillins', 'Concom_Anaesthetics_General', 'Concom_Viral_Vaccines',
'Risk_Type_1_Insulin_Dependent_Diabetes', 'Risk_Osteogenesis_Imperfecta', 'Risk_Rheumatoid_Arthritis',
'Risk_Untreated_Chronic_Hyperthyroidism', 'Risk_Untreated_Chronic_Hypogonadism',
'Risk_Untreated_Early_Menopause', 'Risk_Patient_Parent_Fractured_Their_Hip',
'Risk_Smoking_Tobacco', 'Risk_Chronic_Malnutrition_Or_Malabsorption', 'Risk_Chronic_Liver_Disease',
'Risk_Family_History_Of_Osteoporosis', 'Risk_Low_Calcium_Intake', 'Risk_Vitamin_D_Insufficiency',
'Risk_Poor_Health_Frailty', 'Risk_Excessive_Thinness', 'Risk_Hysterectomy_Oophorectomy',
'Risk_Estrogen_Deficiency', 'Risk_Immobilization', 'Risk_Recurring_Falls','Count_Of_Risks']
encoder=OneHotEncoder(drop='first',sparse=False)
```

In [43]:
```
encoder=OneHotEncoder(drop='first',sparse=False)
encoder_cols=pd.DataFrame(encoder.fit_transform(data[categorical_cols]),columns=encoder.get_feature_names_out(
```

In [44]:
```
encoder_cols
```

Out[44]:

	Ptid_P10	Ptid_P100	Ptid_P1000	Ptid_P1001	Ptid_P1002	Ptid_P1003	Ptid_P1004	Ptid_P1005	Ptid_P1006	Ptid_P1007	...	Risk_E
0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	...	
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	...	
2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	...	
3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	...	
4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	...	
...	...	...	...	...	...	...	...	...	...	...	...	
3419	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	...	
3420	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	...	
3421	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	...	
3422	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	...	
3423	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	...	

3424 rows × 3544 columns

In [45]:
```
x = encoder_cols
y = data['Persistency_Flag']
```

In [46]:
```
x
```

Out[46]:

	Ptid_P10	Ptid_P100	Ptid_P1000	Ptid_P1001	Ptid_P1002	Ptid_P1003	Ptid_P1004	Ptid_P1005	Ptid_P1006	Ptid_P1007	...	Risk_E
0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	...	
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	...	
2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	...	
3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	...	
4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	...	
...	...	...	...	...	...	...	...	...	...	...	...	
3419	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	...	
3420	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	...	
3421	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	...	
3422	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	...	
3423	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	...	

3424 rows × 3544 columns

In [47]:
```
y
```

Out[47]:
```
0           Persistent
1       Non-Persistent
2       Non-Persistent
3       Non-Persistent
4       Non-Persistent
             ...
3419        Persistent
3420        Persistent
3421        Persistent
3422    Non-Persistent
3423    Non-Persistent
Name: Persistency_Flag, Length: 3424, dtype: object
```

In [48]:

```
from sklearn.model_selection import train_test_split
from sklearn.preprocessing import StandardScaler
from sklearn.svm import SVC
from sklearn.metrics import accuracy_score,classification_report
```

In [49]:

```
x_train,x_test,y_train,y_test=train_test_split(x,y,test_size=0.2,random_state=42)
```

In [50]:

```
scaler = StandardScaler()
x_train= scaler.fit_transform(x_train)# train ko sahi karna he bas test ko nahi 5.1asel tar 0.51eraise karto
x_test=scaler.fit_transform(x_test)#trans.. data tranform kaarto =fittrans..fit karta transform karto
```

In [51]:

```
svcm=SVC(kernel='linear')
```

In [52]:

```
svcm.fit(x_train,y_train)
```

Out[52]:

```
▾ SVC
SVC(kernel='linear')
```

In [53]:

```
y_pred=svcm.predict(x_test)
```

In [54]:

```
acc=accuracy_score(y_test,y_pred)
acc
```

Out[54]:

```
0.8072992700729927
```

In [55]:

```
print("Accuracy:{:.2f}%".format(acc*100))
```

```
Accuracy:80.73%
```

In [56]:

```
print(classification_report(y_test,y_pred))#report =classification learn karyala help karto
```

```
                precision    recall  f1-score   support

Non-Persistent       0.81      0.91      0.86       431
    Persistent       0.81      0.63      0.71       254

      accuracy                           0.81       685
     macro avg       0.81      0.77      0.78       685
  weighted avg       0.81      0.81      0.80       685
```

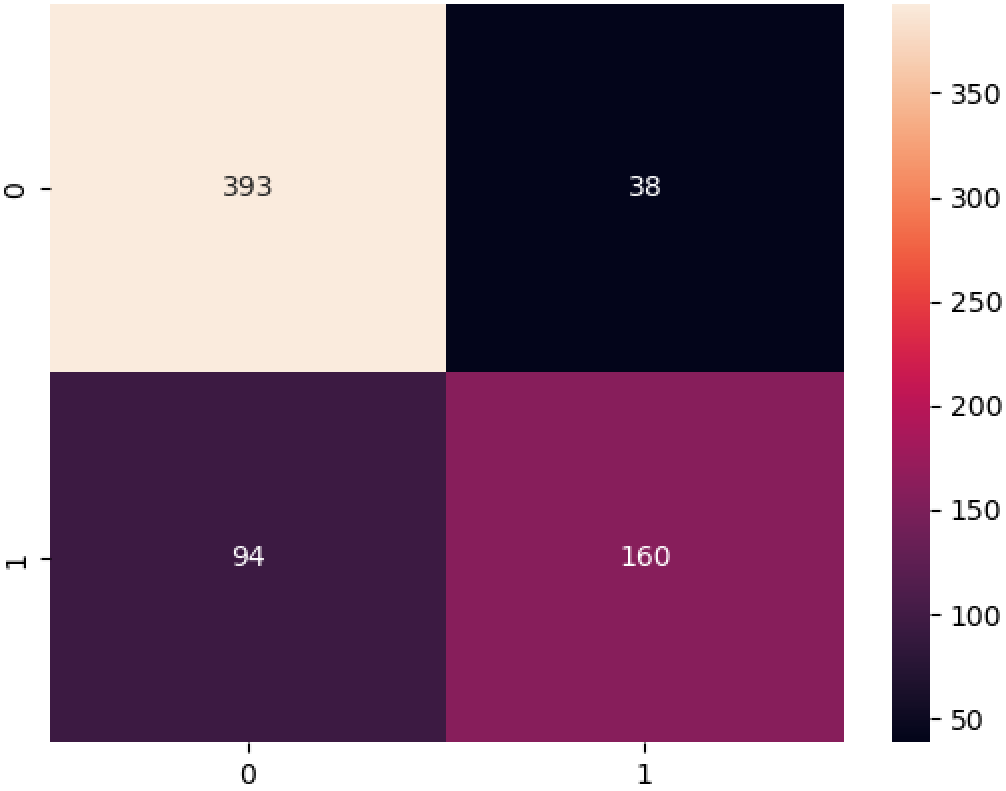
In [57]:

```
from sklearn.metrics import confusion_matrix
cm=confusion_matrix(y_test,y_pred)
print("Confusion Matrix")
print(cm)
```

```
Confusion Matrix
[[393  38]
 [ 94 160]]
```

In [111]:
```
sns.heatmap(cm, annot=True,fmt='.3g')
```

Out[111]:
```
<Axes: >
```



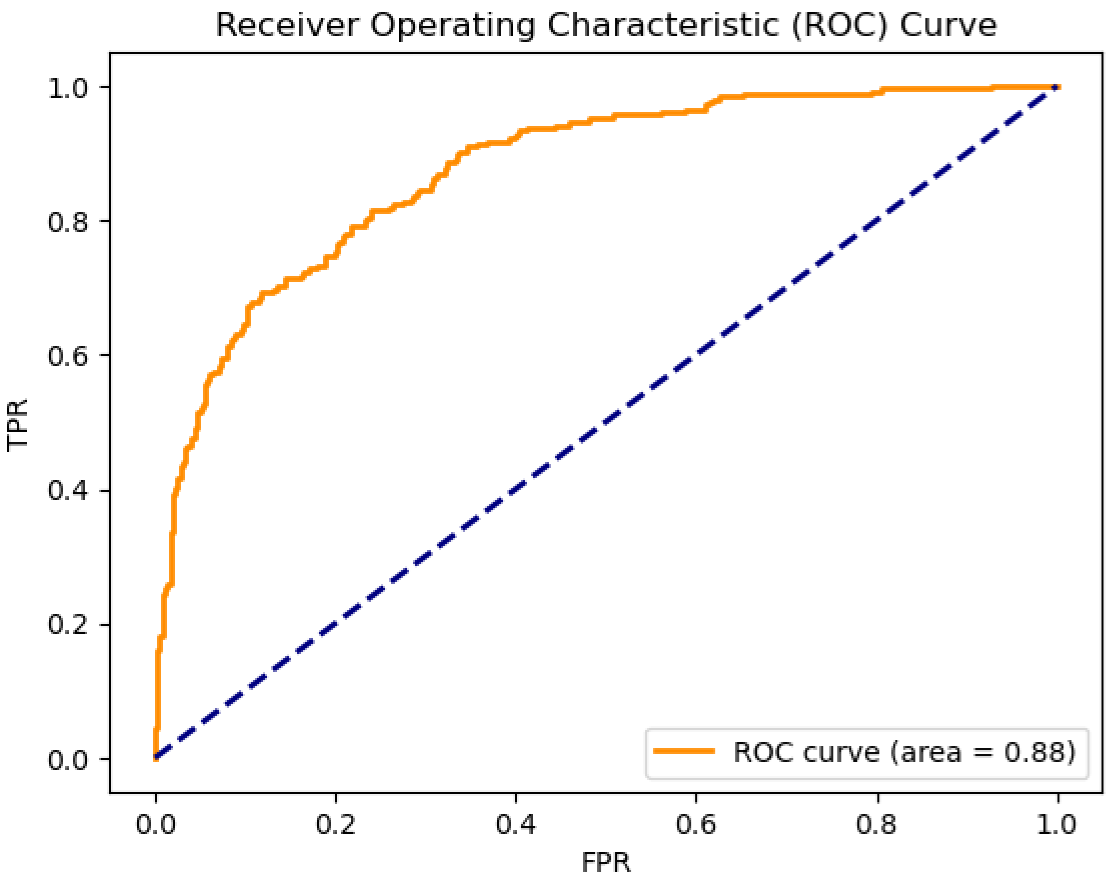
In [99]:
```
from sklearn.svm import SVC
from sklearn.metrics import roc_curve, auc
from sklearn.preprocessing import label_binarize
from sklearn.multiclass import OneVsRestClassifier

yb = label_binarize(y, classes=[0,1])
nc=yb.shape[1]
classifier = OneVsRestClassifier(SVC(kernel="linear", probability=True, random_state=42,decision_function_shap
y_score=classifier.fit(x_train,y_train).decision_function(x_test)
```

In [100]:

```
fpr = dict()
tpr = dict()
roc_auc = dict()

for i in range(nc):
    fpr[i], tpr[i], _ = roc_curve(y_test, y_score, pos_label='Persistent')
    roc_auc[i] = auc(fpr[i], tpr[i])
```

In [101]:

```
plt.figure()
plt.plot(fpr[0], tpr[0], color='darkorange', lw=2, label='ROC curve (area = {:.2f})'.format(roc_auc[0]))
plt.plot([0, 1], [0, 1], 'k--', color='navy', lw=2)
plt.xlabel('FPR')
plt.ylabel('TPR')
plt.title('Receiver Operating Characteristic (ROC) Curve')
plt.legend(loc='lower right')
plt.show()
```



In [59]:
```
from sklearn.metrics import roc_curve, auc
from sklearn.preprocessing import label_binarize
from sklearn.multiclass import OneVsRestClassifier
```

GridSearchCV

In [60]:
```
from sklearn.model_selection import GridSearchCV
```

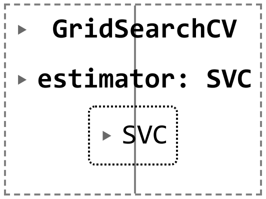
In [61]:
```
param_grid = {
'C' : [0.1, 1, 10, 100],
'kernel' : ['linear', 'rbf', 'poly', 'sigmoid']
}
```

In [62]:
```
svcm = SVC()
```

In [63]:
```
grid_search = GridSearchCV(svcm, param_grid, cv=5)
```

In [64]:
```
grid_search.fit(x_train, y_train)
```

Out[64]:



```
▸ GridSearchCV
▸ estimator: SVC
      ▸ SVC
```

In [65]:
```
best_param = grid_search.best_params_
print("Best hyperparameter : ", best_param)
```

```
Best hyperparameter :  {'C': 10, 'kernel': 'sigmoid'}
```

In [66]:
```
best_svm = SVC(C=best_param['C'], kernel=best_param['kernel'])
```

In [67]:
```
best_svm.fit(x_train, y_train)
```

Out[67]:
```
▾ SVC

SVC(C=10, kernel='sigmoid')
```

In [68]:
```
y_pred = best_svm.predict(x_test)
acc = accuracy_score(y_test, y_pred)
print("Accuracy : {:.2f}%". format(acc * 100))
```

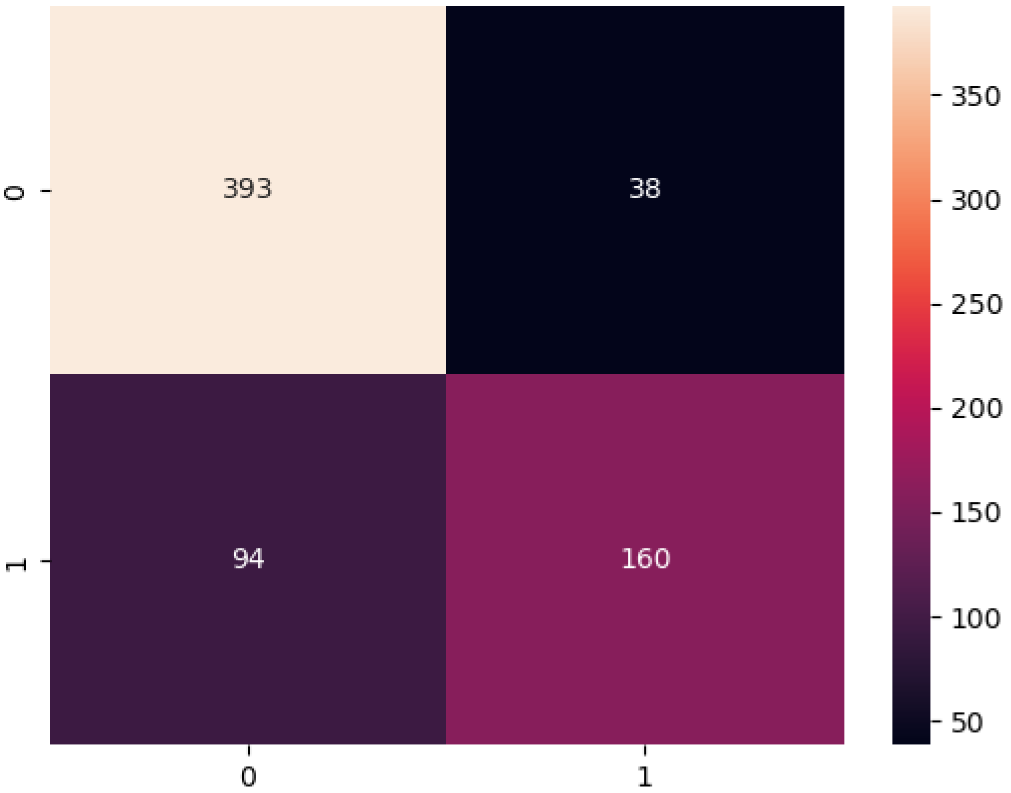
```
Accuracy : 81.17%
```

In [69]:
```
cm=confusion_matrix(y_test,y_pred)
print("Confusion Matrix : ")
print(cm)
```

```
Confusion Matrix :
[[392  39]
 [ 90 164]]
```

In [110]:

```
sns.heatmap(cm, annot=True,fmt='.3g')
plt.show()
```



Random Search

In [94]:

```

from sklearn.model_selection import RandomizedSearchCV
```

In [95]:

```
 param_grid = {
'C' : [0.1, 1, 10, 100],
'kernel' : ['linear', 'rbf', 'poly', 'sigmoid']
}
```

In [96]:

```
svcm = SVC()
```

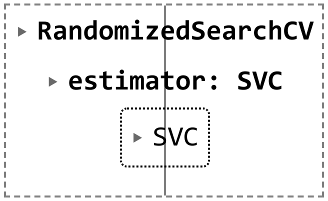
In [97]:

```
random_search = RandomizedSearchCV(svcm, param_grid, cv=5)
```

In [98]:

```
random_search.fit(x_train, y_train)
```

Out[98]:



▸ RandomizedSearchCV

▸ estimator: SVC

▸ SVC

In [103]:

```
best_parameters = random_search.best_params_
best_model = random_search.best_estimator_
print('Hyperparameters:',best_parameters)
```

```
Hyperparameters: {'kernel': 'linear', 'C': 0.1}
```

In [104]:

```
y_pred = best_model.predict(x_test)
```

In [106]:

```
acc=accuracy_score(y_test,y_pred)
print("Accuracy:",acc)
```

```
Accuracy: 0.8072992700729927
```

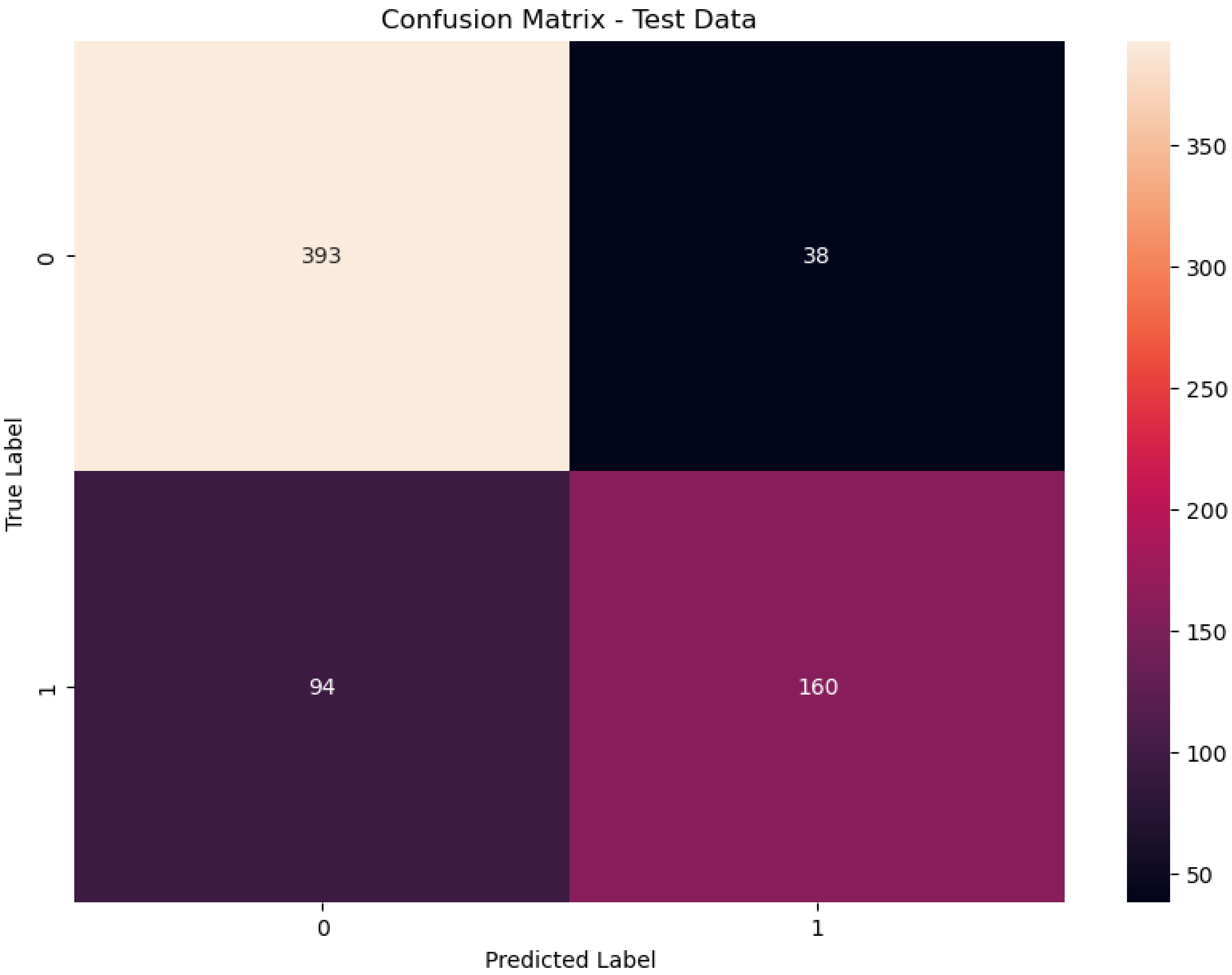
In [108]:
```
print(classification_report(y_test,y_pred))
```

```
                precision    recall  f1-score   support

Non-Persistent       0.81      0.91      0.86       431
    Persistent       0.81      0.63      0.71       254

      accuracy                           0.81       685
     macro avg       0.81      0.77      0.78       685
  weighted avg       0.81      0.81      0.80       685
```

In [109]:

```
cm = confusion_matrix(y_test,y_pred)
print('Confusion Matrix: ',cm)
plt.figure(figsize = (10,7))
sns.heatmap(cm, annot=True, fmt='.3g')
plt.title('Confusion Matrix - Test Data')
plt.xlabel('Predicted Label')
plt.ylabel('True Label')
plt.show()
```

```
Confusion Matrix:  [[393  38]
 [ 94 160]]
```


Confusion Matrix - Test Data
True Label
Predicted Label
0
1
0
1
393
38
94
160
350
300
250
200
150
100
50

Naive Bayes

In [112]:
```
 from sklearn import model_selection, naive_bayes, metrics,feature_extraction
```

In [114]:
```
x_train,x_test,y_train,y_test=train_test_split(x,y,test_size=0.25,random_state=42)
```

In [115]:
```
from sklearn.preprocessing import MinMaxScaler
scaler = MinMaxScaler()
x_train = scaler.fit_transform(x_train)
x_test = scaler.transform(x_test)
```

In [116]:
```
bayes = naive_bayes.MultinomialNB()
```

In [117]:
```
bayes.fit(x_train,y_train)
```

Out[117]:
```
▾ MultinomialNB

MultinomialNB()
```

In [118]:
```
y_pred_nb=bayes.predict(x_test)
```

In [119]:
```
accuracy=metrics.accuracy_score(y_test,y_pred_nb)
accuracy
```

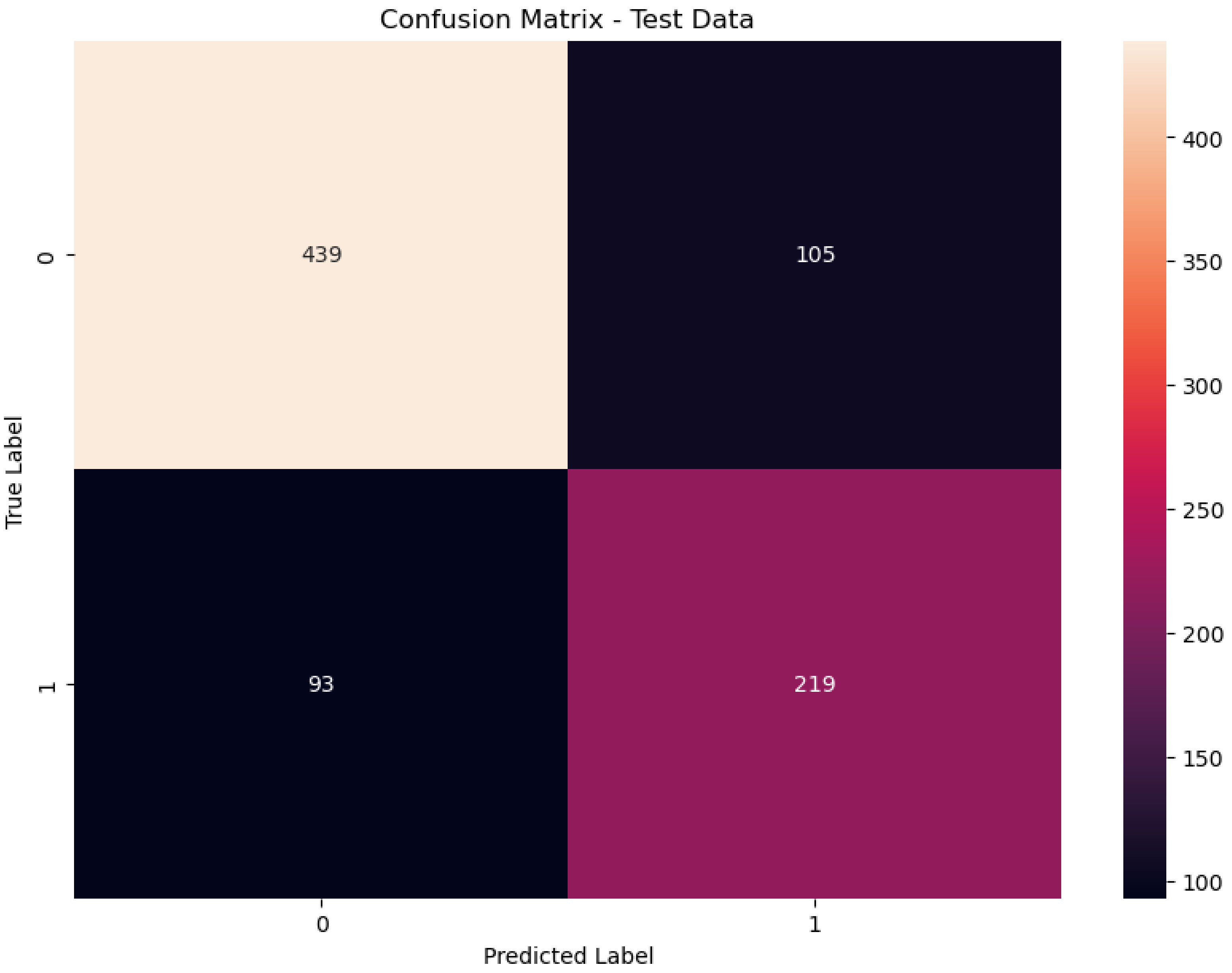
Out[119]:
```
0.7686915887850467
```

In [120]:
```
print(metrics.classification_report(y_test, y_pred_nb))
```

```
                precision    recall  f1-score   support

Non-Persistent       0.83      0.81      0.82       544
    Persistent       0.68      0.70      0.69       312

      accuracy                           0.77       856
     macro avg       0.75      0.75      0.75       856
  weighted avg       0.77      0.77      0.77       856
```

In [121]:

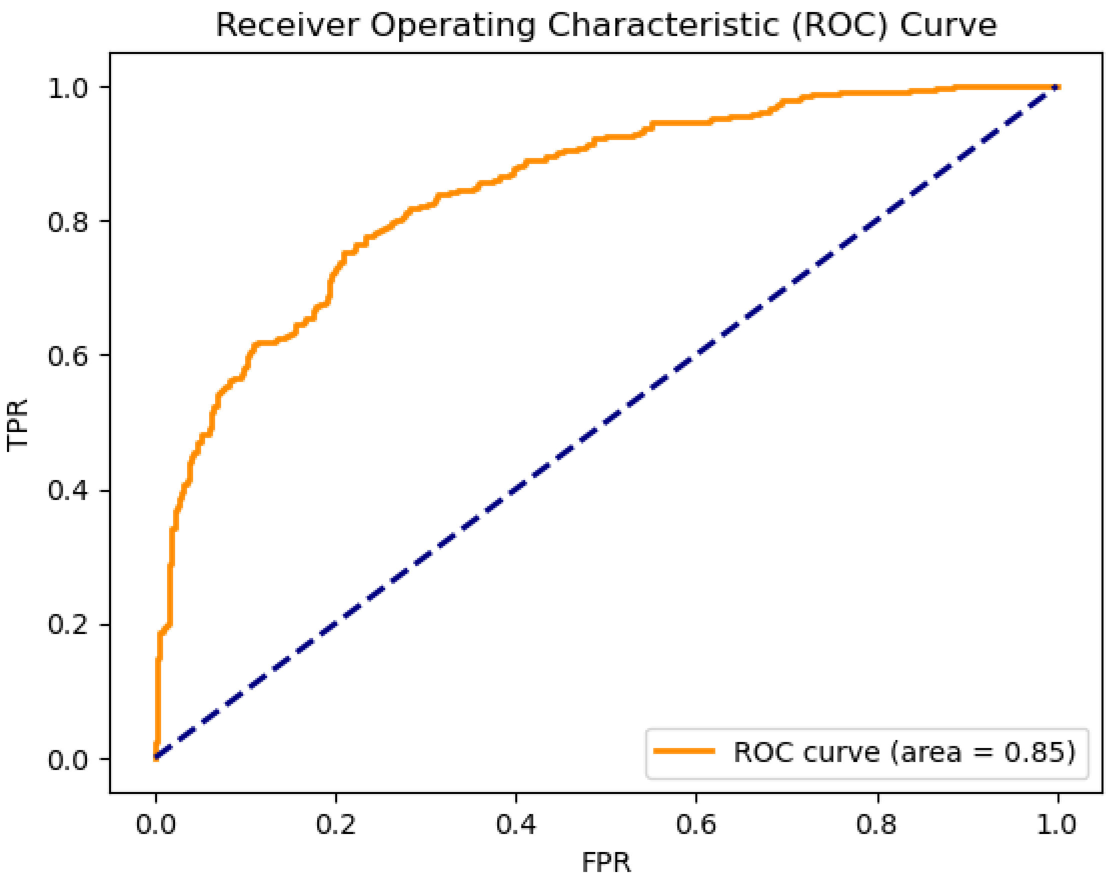
```
cm=confusion_matrix(y_test,y_pred_nb)
cm
plt.figure(figsize = (10,7))
sns.heatmap(cm, annot=True, fmt='.3g')
plt.title('Confusion Matrix - Test Data')
plt.xlabel('Predicted Label')
plt.ylabel('True Label')
plt.show()
```


Confusion Matrix - Test Data
439
105
93
219
True Label
0
1
Predicted Label
0
1
400
350
300
250
200
150
100

In [125]:

```
from sklearn.metrics import roc_curve, auc

fpr = dict()
tpr = dict()
roc_auc = dict()

for i in range(nc):
    y_score = bayes.predict_proba(x_test)[:, 1]  # Assuming 'Persistent' is the positive class
    fpr[i], tpr[i], _ = roc_curve(y_test, y_score, pos_label='Persistent')
    roc_auc[i] = auc(fpr[i], tpr[i])
```

In [126]:
```
plt.figure()
plt.plot(fpr[0], tpr[0], color='darkorange', lw=2, label='ROC curve (area = {:.2f})'.format(roc_auc[0]))
plt.plot([0, 1], [0, 1], 'k--', color='navy', lw=2)
plt.xlabel('FPR')
plt.ylabel('TPR')
plt.title('Receiver Operating Characteristic (ROC) Curve')
plt.legend(loc='lower right')
plt.show()
```



Tuning for Naive Bayes Model

In [127]:

```
 param_grid = {
'alpha': [0.1, 1, 10, 100],
'fit_prior': [True, False]
}
```

In [128]:

```
bayes = naive_bayes.MultinomialNB()
grid_search = GridSearchCV(bayes, param_grid, cv=5)
grid_search.fit(x_train, y_train)
```

Out[128]:

```
▸       GridSearchCV
▸ estimator: MultinomialNB
        ▸ MultinomialNB
```

In [129]:

```
best_param = grid_search.best_params_
best_nb = naive_bayes.MultinomialNB(alpha = best_param['alpha'], fit_prior = best_param['fit_prior'])
best_nb.fit(x_train, y_train)
y_pred = best_nb.predict(x_test)
```

In [130]:

```
print("Best Hyperparameter : ", best_param)
```

```
Best Hyperparameter :  {'alpha': 1, 'fit_prior': True}
```

In [131]:

```
acc = accuracy_score(y_test, y_pred)
print('Accuracy',acc)
```

```
Accuracy 0.7686915887850467
```

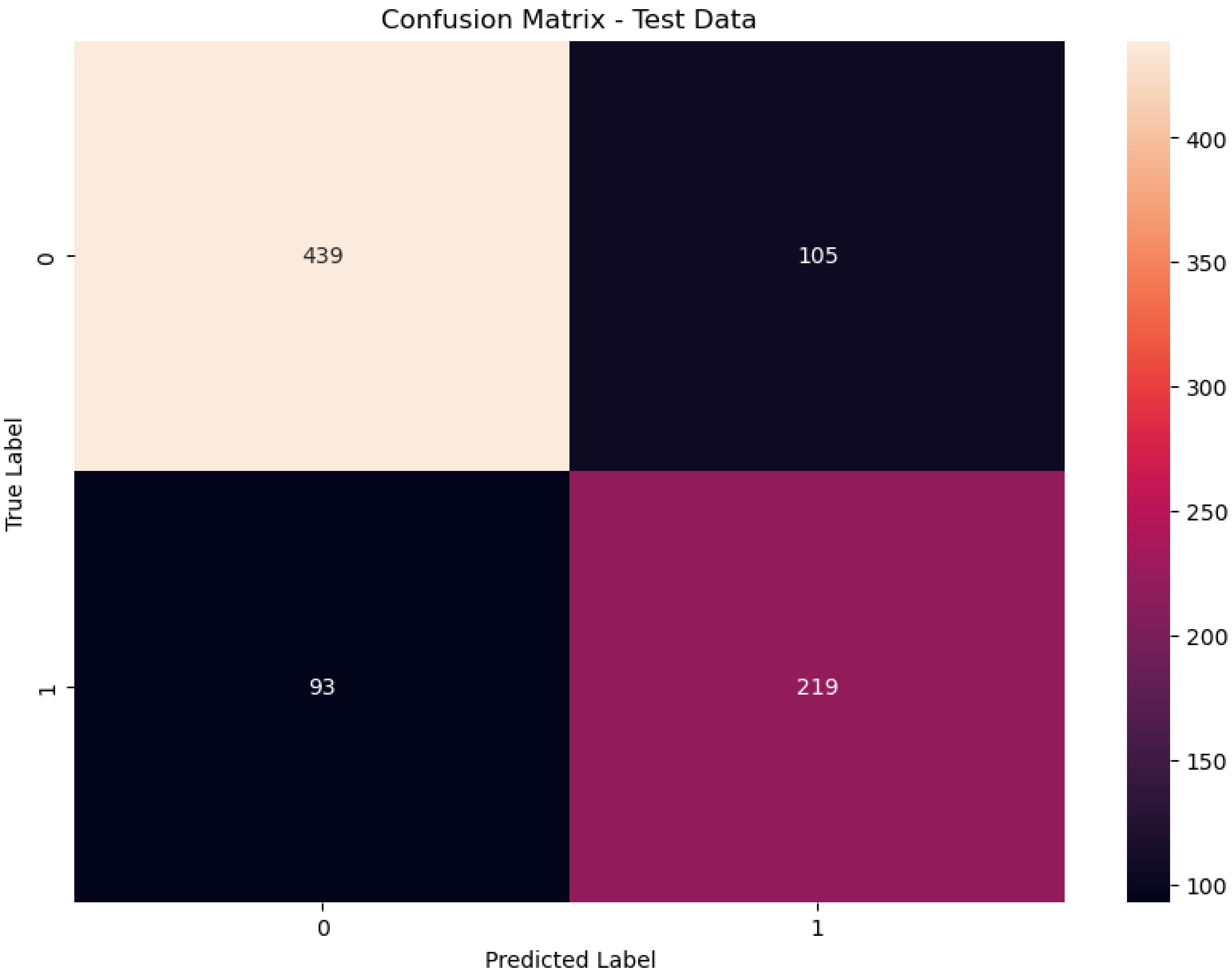
In [132]:

```
print (classification_report(y_test,y_pred))
```

```
                precision    recall  f1-score   support

Non-Persistent       0.83      0.81      0.82       544
    Persistent       0.68      0.70      0.69       312

      accuracy                           0.77       856
     macro avg       0.75      0.75      0.75       856
  weighted avg       0.77      0.77      0.77       856
```

In [133]:

```
cm=confusion_matrix(y_test,y_pred)
cm
plt.figure(figsize = (10,7))
sns.heatmap(cm, annot=True, fmt='.3g')
plt.title('Confusion Matrix - Test Data')
plt.xlabel('Predicted Label')
plt.ylabel('True Label')
plt.show()
```



Randomized Search

In [134]:

```
from scipy.stats import uniform
param_dist = {
    'alpha': uniform(0.1, 2.0),  # Example: Uniform distribution for alpha
    'fit_prior':[True,False]
}
```

In [135]:

```
bayes = naive_bayes.MultinomialNB()
```

In [136]:

```
from sklearn.utils.validation import check_non_negative
check_non_negative(x, "MultinomialNB (input x)")
```

In [138]:

```
randomized_search = RandomizedSearchCV(bayes, param_distributions=param_dist, n_iter=10, scoring='accuracy', c
randomized_search.fit(x, y)  # X is your input data, y is your target labels
```

Out[138]:

```
▸    RandomizedSearchCV
▸ estimator: MultinomialNB
        ▸ MultinomialNB
```

In [139]:

```
best_param = randomized_search.best_params_
print("Best Hyperparameter : ", best_param)
```

```
Best Hyperparameter :  {'alpha': 1.4195573464854765, 'fit_prior': True}
```

In [140]:

```
best_nb = naive_bayes.MultinomialNB(alpha = best_param['alpha'], fit_prior = best_param['fit_prior'])
best_nb.fit(x_train, y_train)
y_pred = best_nb.predict(x_test)
```

In [141]:

```
acc = accuracy_score(y_test, y_pred)
print('Accuracy',acc)
```

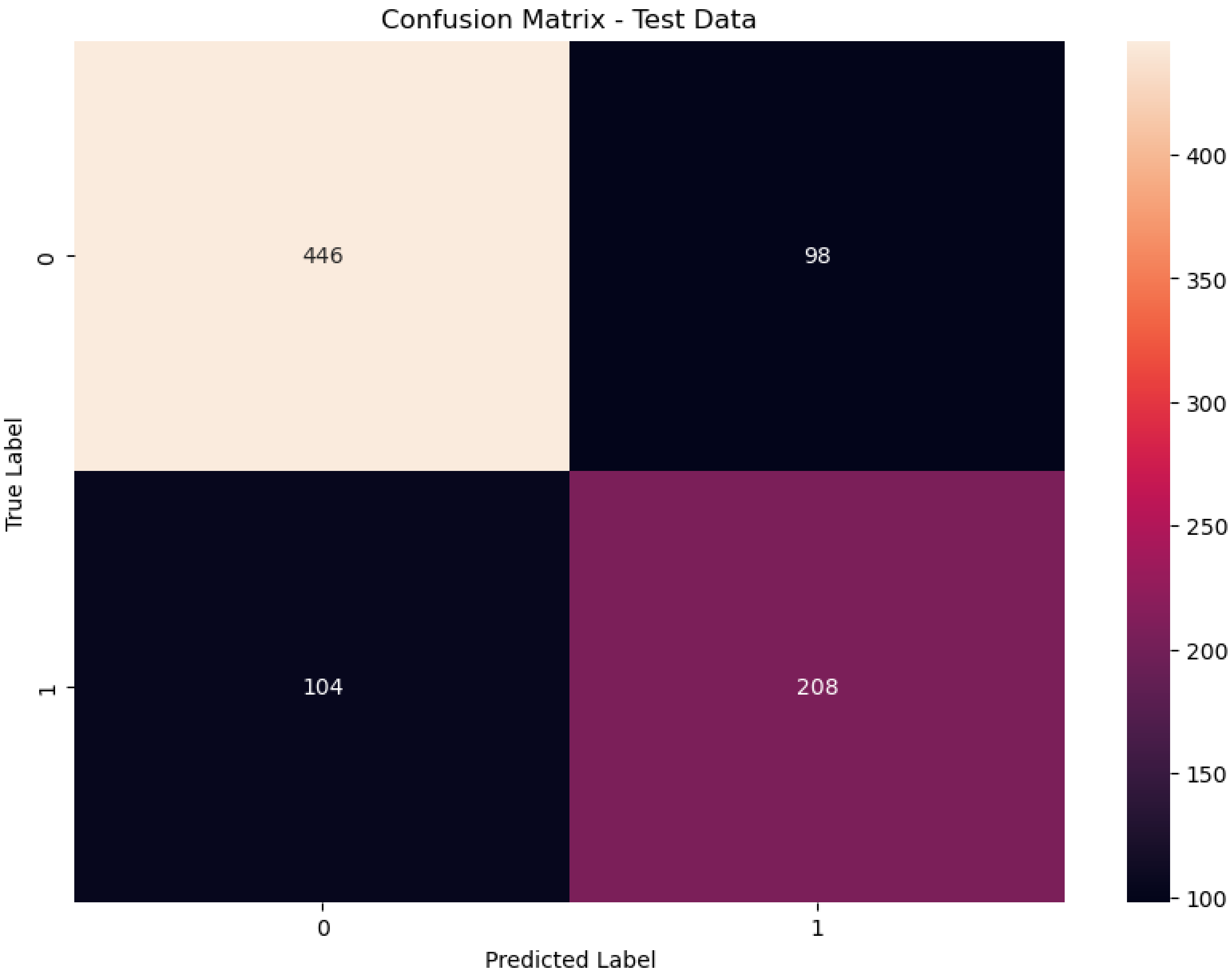
```
Accuracy 0.764018691588785
```

```
In [142]: print(classification_report(y_test, y_pred))
```

```
                precision    recall  f1-score   support

Non-Persistent       0.81      0.82      0.82       544
    Persistent       0.68      0.67      0.67       312

      accuracy                           0.76       856
     macro avg       0.75      0.74      0.74       856
  weighted avg       0.76      0.76      0.76       856
```

In [143]:

```
cm=confusion_matrix(y_test,y_pred)
cm
plt.figure(figsize = (10,7))
sns.heatmap(cm, annot=True, fmt='.3g')
plt.title('Confusion Matrix - Test Data')
plt.xlabel('Predicted Label')
plt.ylabel('True Label')
plt.show()
```


Confusion Matrix - Test Data
446
98
104
208
True Label
0
1
Predicted Label
0
1
400
350
300
250
200
150
100

```
In [ ]:
```