PROJECT NAME : ANALYTICS FOR HOSPITAL HEALTH CARE – DATA

TEAM ID : PNT2022TMID16326

```
import os
for dirname, _, filenames in os.walk('input'):
    for filename in filenames:
        print(os.path.join(dirname, filename))

import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
from matplotlib.colors import ListedColormap
import seaborn as sns
from warnings import filterwarnings
filterwarnings('ignore')
pd.options.display.max_columns = None
pd.options.display.max_rows = None
pd.options.display.float_format = '{:.6f}'.format
from sklearn.model_selection import train_test_split
import statsmodels
import statsmodels.api as sm
from sklearn.preprocessing import StandardScaler
from sklearn import metrics
from sklearn.linear_model import LogisticRegression
from sklearn.metrics import classification_report
from sklearn.metrics import cohen_kappa_score
from sklearn.metrics import confusion_matrix
from sklearn.metrics import roc_curve
from sklearn.metrics import accuracy_score
from sklearn.tree import DecisionTreeClassifier
from sklearn.ensemble import RandomForestClassifier
from sklearn import tree
from sklearn.model_selection import GridSearchCV
from sklearn.ensemble import
AdaBoostClassifier,GradientBoostingClassifier
from catboost import CatBoostClassifier
from sklearn.feature_selection import RFE
plt.rcParams['figure.figsize'] = [15,8]

train = pd.read_csv("D:/HealthCare/train_data.csv")
test = pd.read_csv("D:/HealthCare/test_data.csv")

train.head()
```

	case_id	Hospital_code	Hospital_type_code	City_Code_Hospital	\
0	1	8	c	3	
1	2	2	c	5	
2	3	10	e	1	
3	4	26	b	2	
4	5	26	b	2	

```
  Hospital_region_code Available Extra Rooms in Hospital
Department \
```

```
radiotherapy
1                   Z                                   2
radiotherapy
2                   X                                   2
anesthesia
3                   Y                                   2
radiotherapy
4                   Y                                   2
radiotherapy

  Ward_Type Ward_Facility_Code Bed Grade patientid
City_Code_Patient \
0         R                  F   2.000000      31397
7.000000
1         S                  F   2.000000      31397
7.000000
2         S                  E   2.000000      31397
7.000000
3         R                  D   2.000000      31397
7.000000
4         S                  D   2.000000      31397
7.000000

  Type of Admission Severity of Illness  Visitors with Patient    Age
\
0         Emergency             Extreme                     2  51-60

1            Trauma             Extreme                     2  51-60

2            Trauma             Extreme                     2  51-60

3            Trauma             Extreme                     2  51-60

4            Trauma             Extreme                     2  51-60


   Admission_Deposit   Stay
0        4911.000000   0-10
1        5954.000000  41-50
2        4745.000000  31-40
3        7272.000000  41-50
4        5558.000000  41-50

print(train.shape)
print(test.shape)

(318438, 18)
(137057, 17)

train.dtypes
```

```
case_id                                int64
Hospital_code                          int64
Hospital_type_code                    object
City_Code_Hospital                     int64
Hospital_region_code                  object
Available Extra Rooms in Hospital      int64
Department                            object
Ward_Type                             object
Ward_Facility_Code                    object
Bed Grade                            float64
patientid                              int64
City_Code_Patient                    float64
Type of Admission                     object
Severity of Illness                   object
Visitors with Patient                  int64
Age                                   object
Admission_Deposit                    float64
Stay                                  object
dtype: object
```

```
train.nunique()
```

```
case_id                              318438
Hospital_code                            32
Hospital_type_code                        7
City_Code_Hospital                       11
Hospital_region_code                      3
Available Extra Rooms in Hospital        18
Department                                5
Ward_Type                                 6
Ward_Facility_Code                        6
Bed Grade                                 4
patientid                             92017
City_Code_Patient                        37
Type of Admission                         3
Severity of Illness                       3
Visitors with Patient                    28
Age                                      10
Admission_Deposit                      7300
Stay                                     11
dtype: int64
```

```
train.duplicated().sum()
```

```
0
```

```
train['Hospital_code'] = train['Hospital_code'].astype(object)
train['City_Code_Hospital'] =
train['City_Code_Hospital'].astype(object)
train['Available Extra Rooms in Hospital'] = train['Available Extra
Rooms in Hospital'].astype(object)
```

```
train['Bed Grade'] = train['Bed Grade'].astype(object)
train['City_Code_Patient'] = train['City_Code_Patient'].astype(object)

train.dtypes

case_id                                int64
Hospital_code                         object
Hospital_type_code                    object
City_Code_Hospital                    object
Hospital_region_code                  object
Available Extra Rooms in Hospital     object
Department                            object
Ward_Type                             object
Ward_Facility_Code                    object
Bed Grade                             object
patientid                              int64
City_Code_Patient                     object
Type of Admission                     object
Severity of Illness                   object
Visitors with Patient                  int64
Age                                   object
Admission_Deposit                    float64
Stay                                  object
dtype: object

test['Hospital_code'] = test['Hospital_code'].astype(object)
test['City_Code_Hospital'] = test['City_Code_Hospital'].astype(object)
test['Available Extra Rooms in Hospital'] = test['Available Extra
Rooms in Hospital'].astype(object)
test['Bed Grade'] = test['Bed Grade'].astype(object)
test['City_Code_Patient'] = test['City_Code_Patient'].astype(object)

test.dtypes

case_id                                int64
Hospital_code                         object
Hospital_type_code                    object
City_Code_Hospital                    object
Hospital_region_code                  object
Available Extra Rooms in Hospital     object
Department                            object
Ward_Type                             object
Ward_Facility_Code                    object
Bed Grade                             object
patientid                              int64
City_Code_Patient                     object
Type of Admission                     object
Severity of Illness                   object
Visitors with Patient                  int64
Age                                   object
```

```
Admission_Deposit                    float64
dtype: object
```

```
train.drop(['case_id', 'patientid'], axis=1, inplace=True)
```

```
test.drop(['case_id', 'patientid'], axis=1, inplace=True)
```

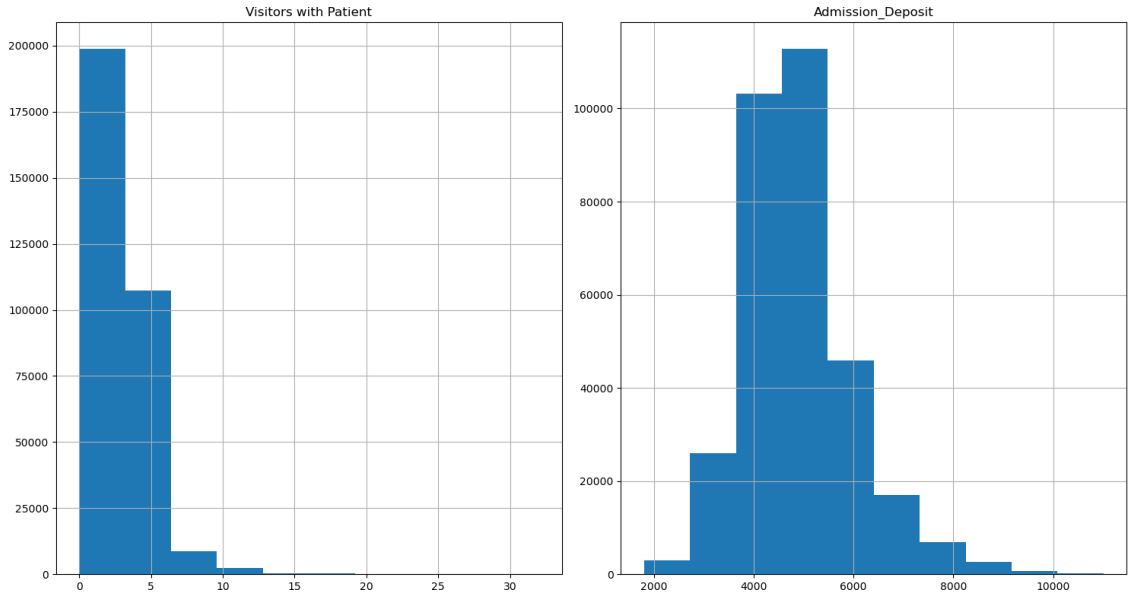
```
train['Stay'] .replace ('More than 100 Days', '100+', inplace=True)
```

```
plt.figure(figsize=(15,8))
```

```
train.drop('Stay', axis = 1).hist()
plt.tight_layout()
plt.show()
```

```
print('Skewness:')
train.drop('Stay', axis = 1).skew()
```

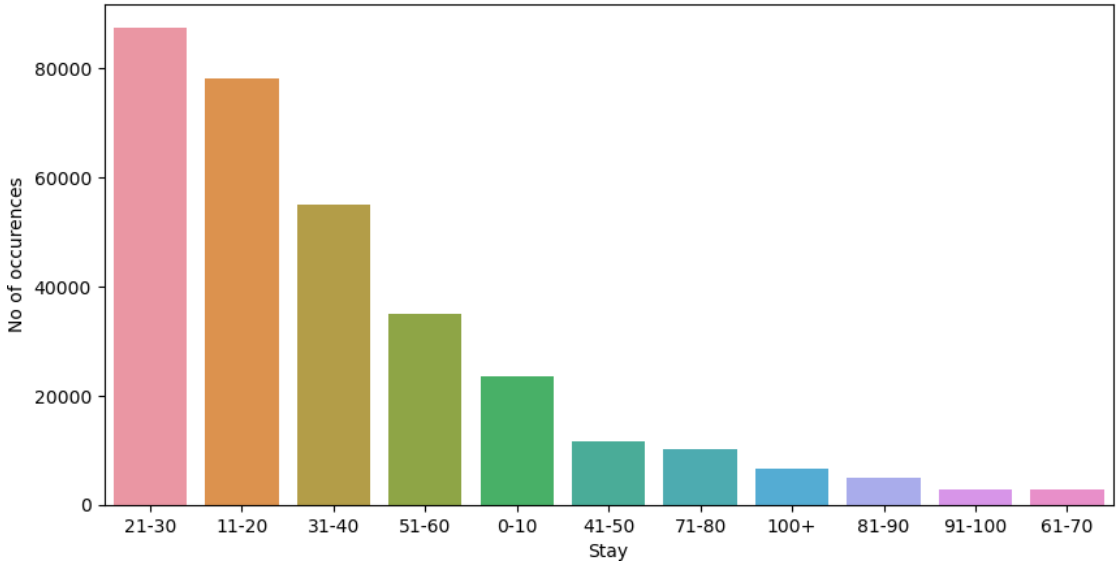
```
<Figure size 1500x800 with 0 Axes>
```

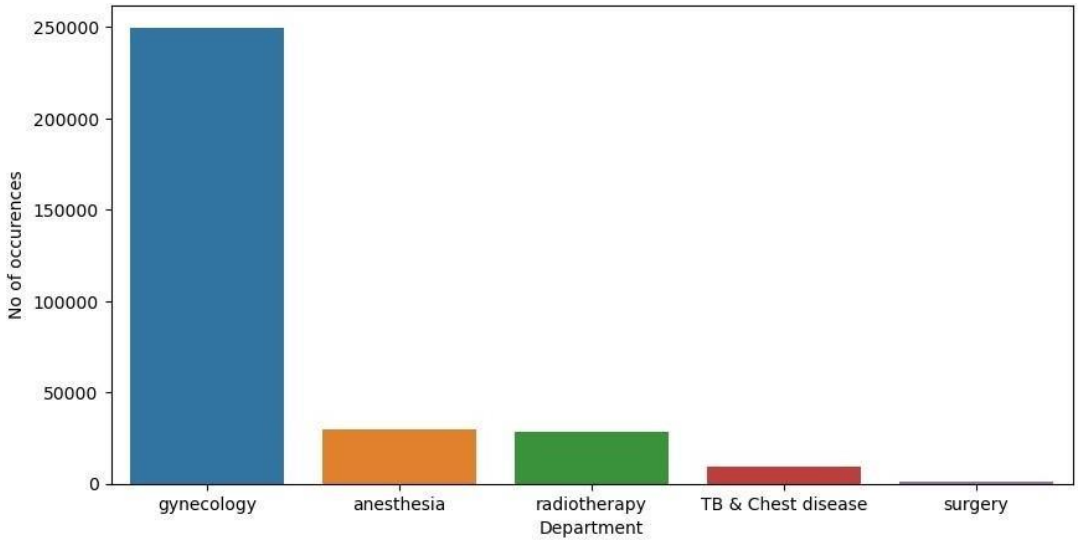


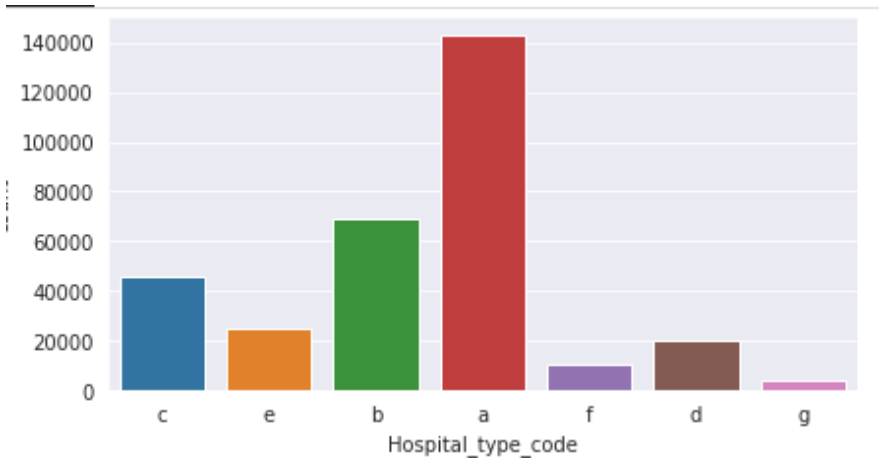

```
Skewness:

Hospital_code                          -0.280783
City_Code_Hospital                      0.538809
Available Extra Rooms in Hospital       0.971930
Bed Grade                               0.051754
City_Code_Patient                       1.581736
Visitors with Patient                   3.137125
Admission_Deposit                       0.931454
dtype: float64
```

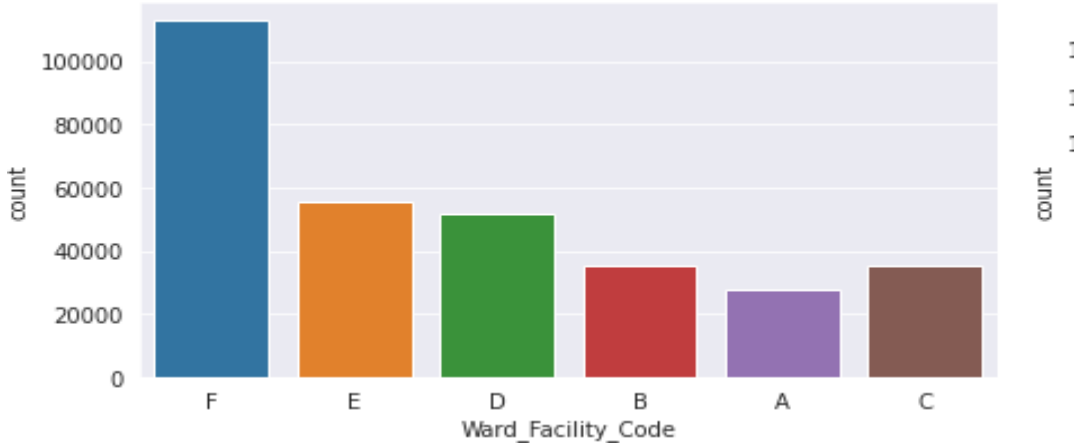
```
train['Stay'] .replace('More than 100 Days', '>100', inplace=True)
```

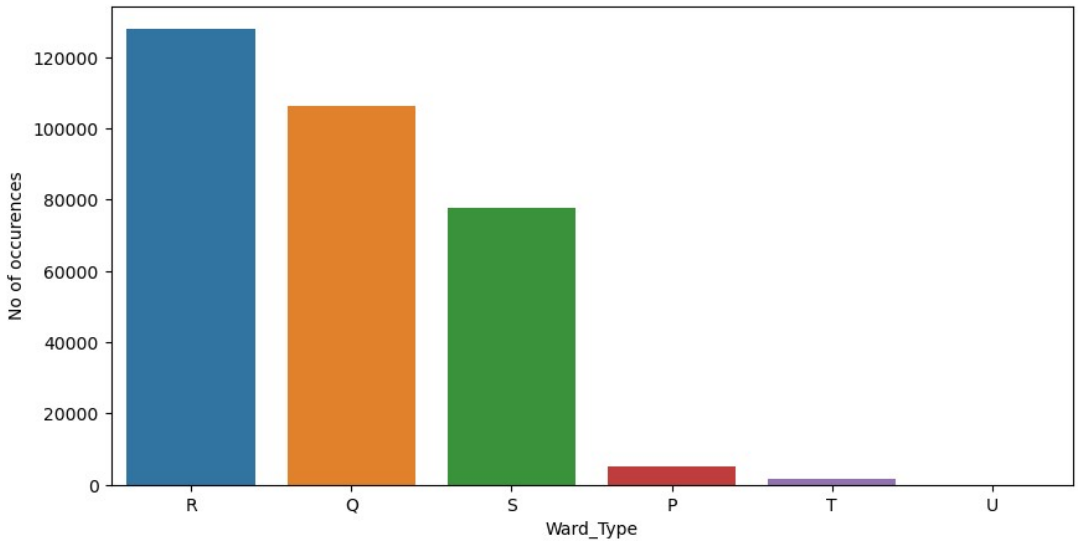
```
for i in [ 'Stay', 'Department', 'Available Extra Rooms in Hospital',
'Ward_Type' ,'Ward_Facility_Code', 'Age',
          'Type of Admission', 'Severity of Illness', 'Bed Grade',
'Hospital_region_code', 'Hospital_type_code' ,
          'City_Code_Hospital', 'Hospital_code', 'City_Code_Patient',
'Visitors with Patient']:
            count = train[i].value_counts()

            plt.figure(figsize=(10,5))

            sns.barplot(x=count.index.values,
y=count.values,data=train)

            plt.xlabel(i)
            plt.ylabel('No of occurences')
```

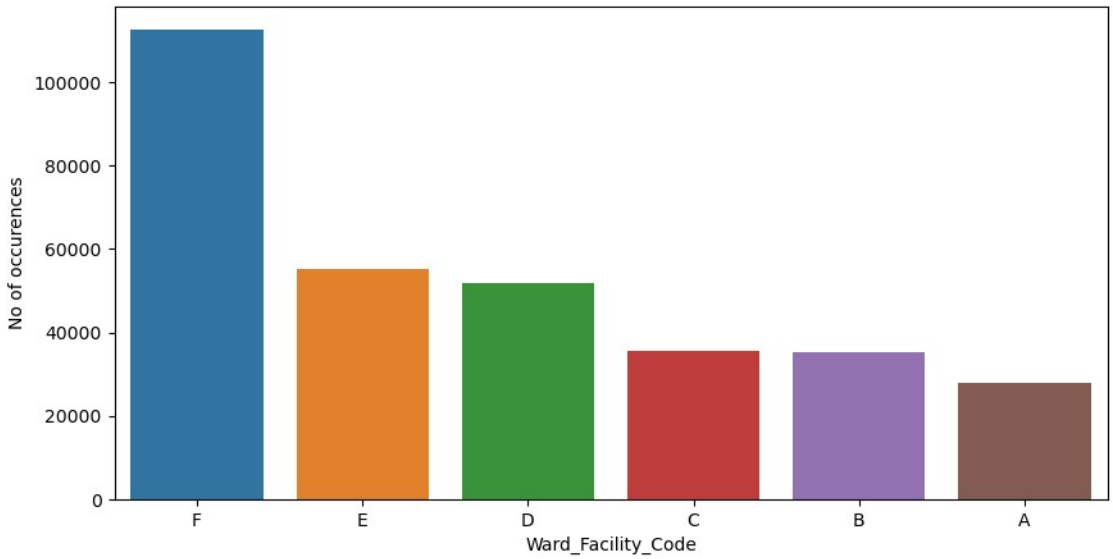


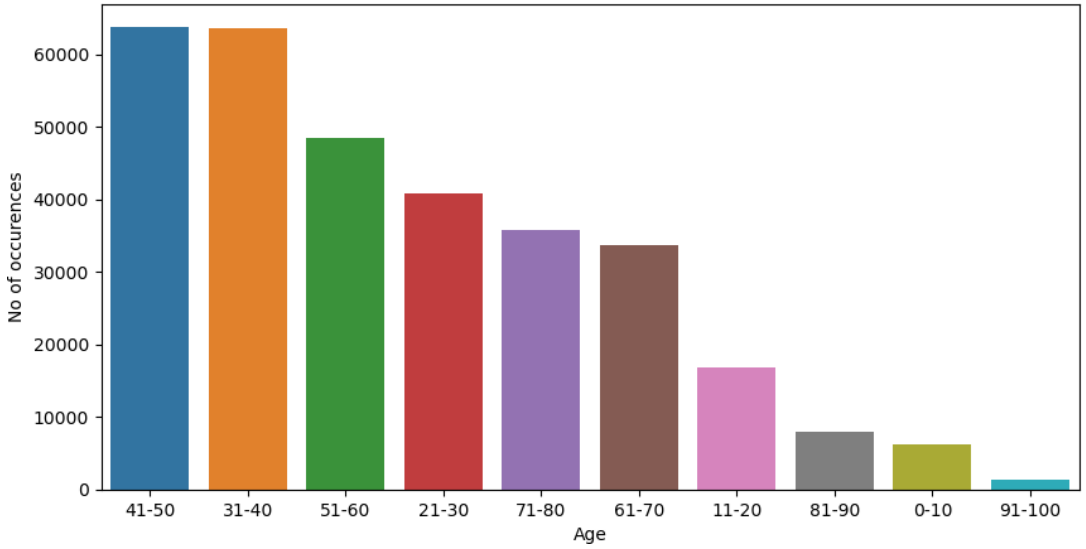


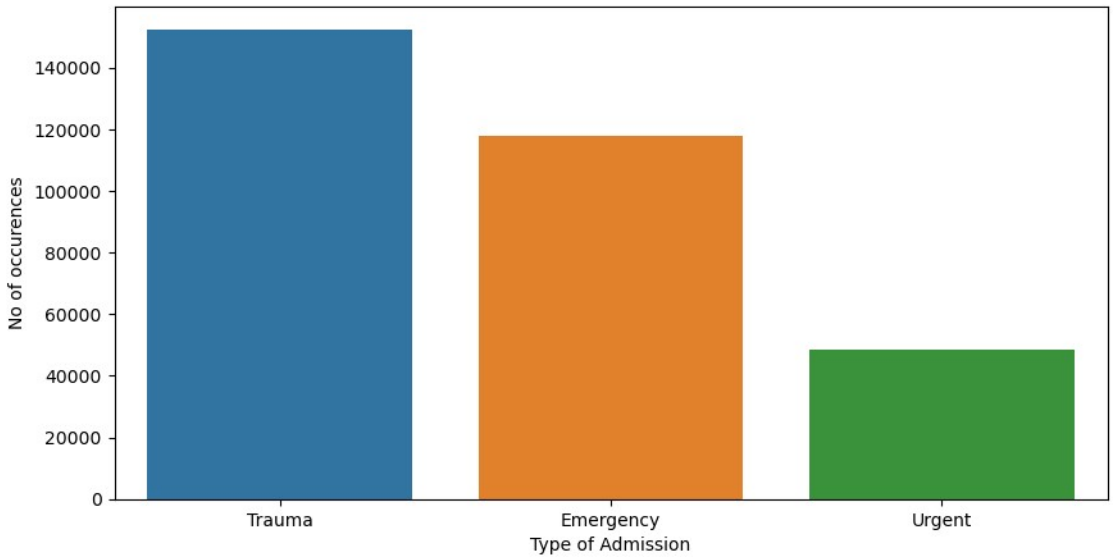

140000
120000
100000
80000
60000
40000
20000
0
c
e
b
a
f
d
g
Hospital_type_code

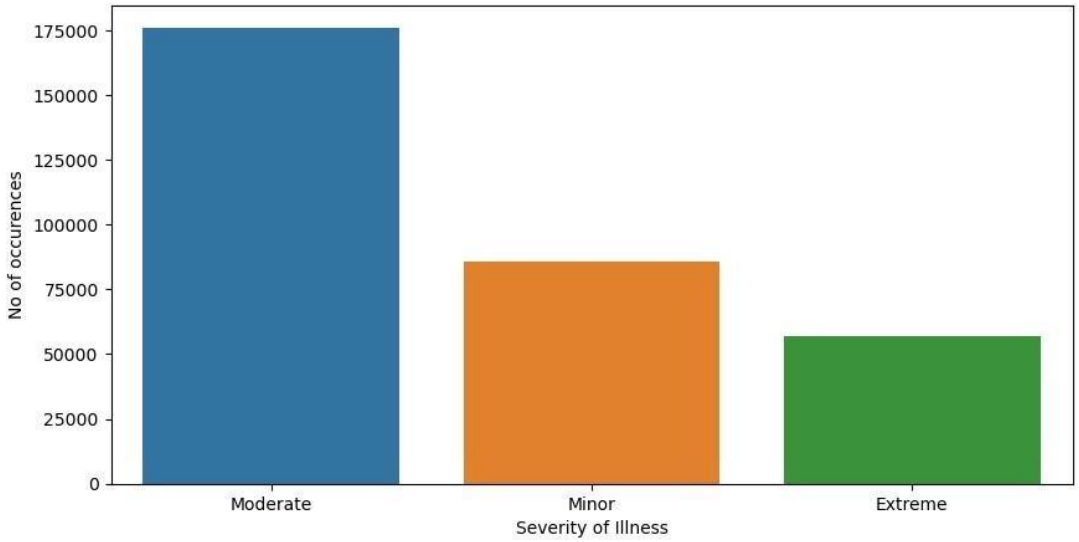

100000
80000
60000
40000
20000
0
count
F
E
D
B
A
C
Ward_Facility_Code

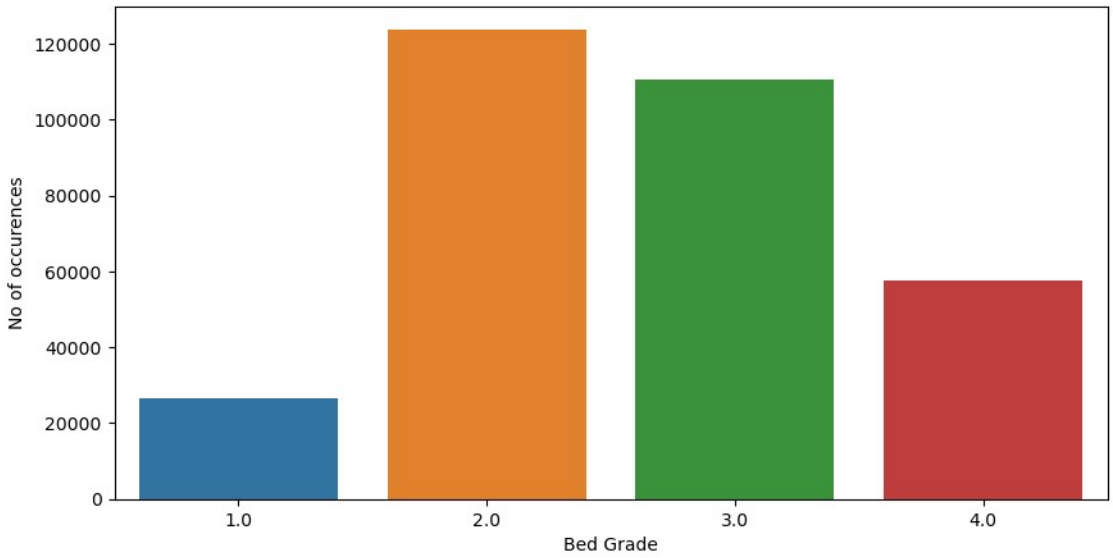

120000
100000
80000
60000
40000
20000
0
No of occurences
R
Q
S
P
T
U
Ward_Type

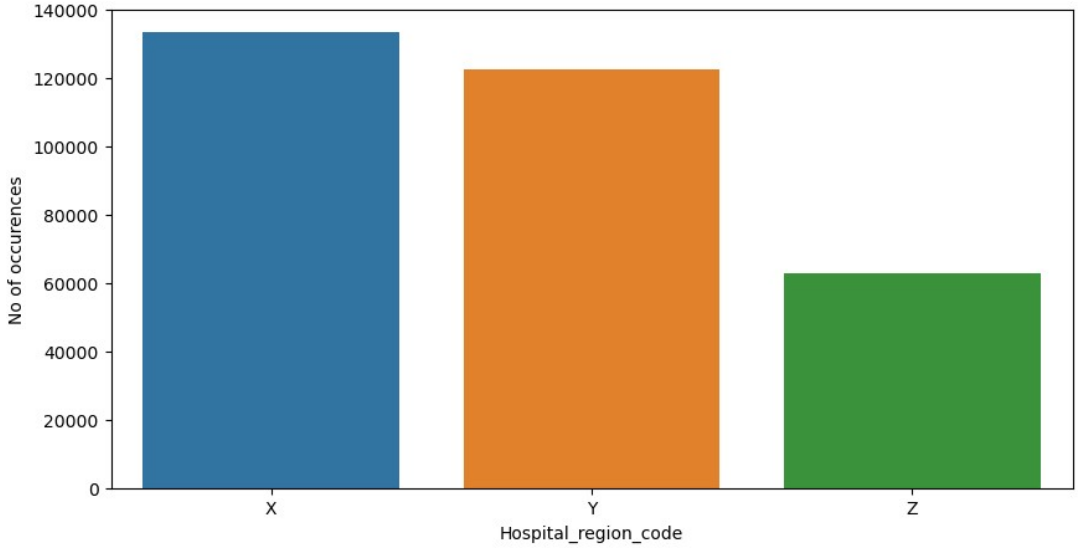

No of occurences
100000
80000
60000
40000
20000
0
F
E
D
C
B
A
Ward_Facility_Code

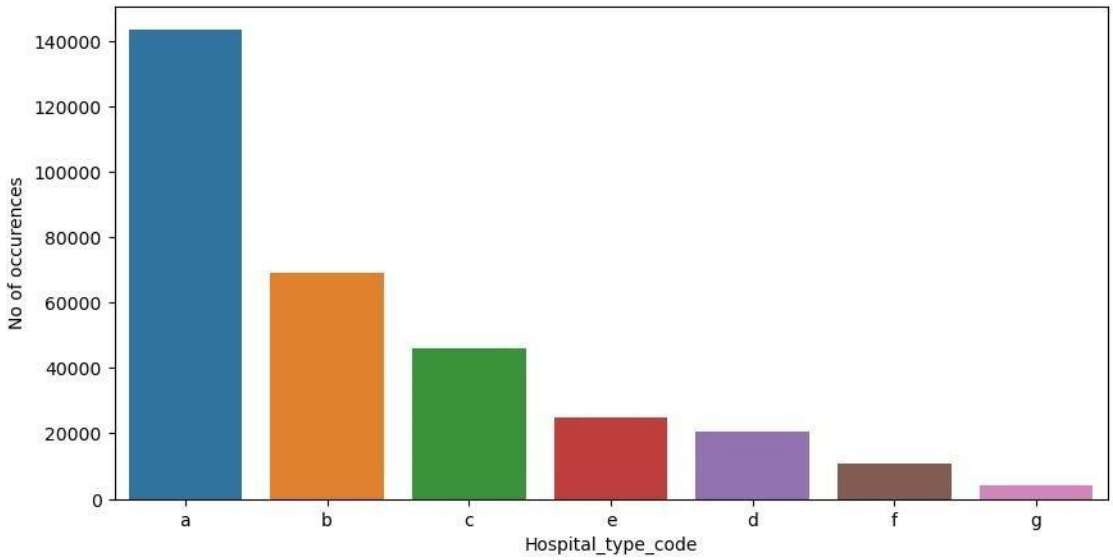

No of occurences
60000
50000
40000
30000
20000
10000
0
41-50
31-40
51-60
21-30
71-80
61-70
11-20
81-90
0-10
91-100
Age

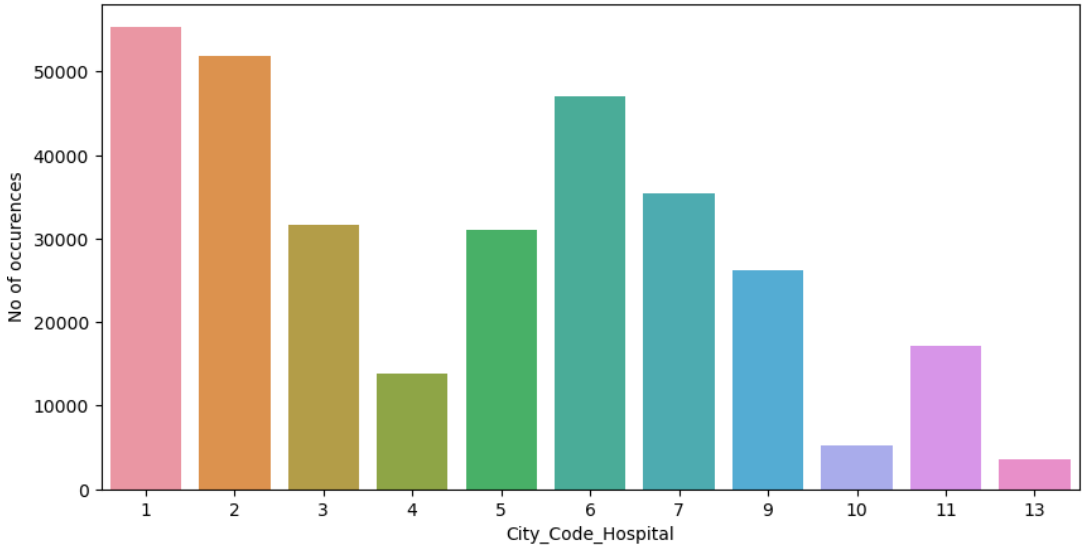

140000
120000
100000
80000
60000
40000
20000
0
No of occurences
Trauma
Emergency
Urgent
Type of Admission

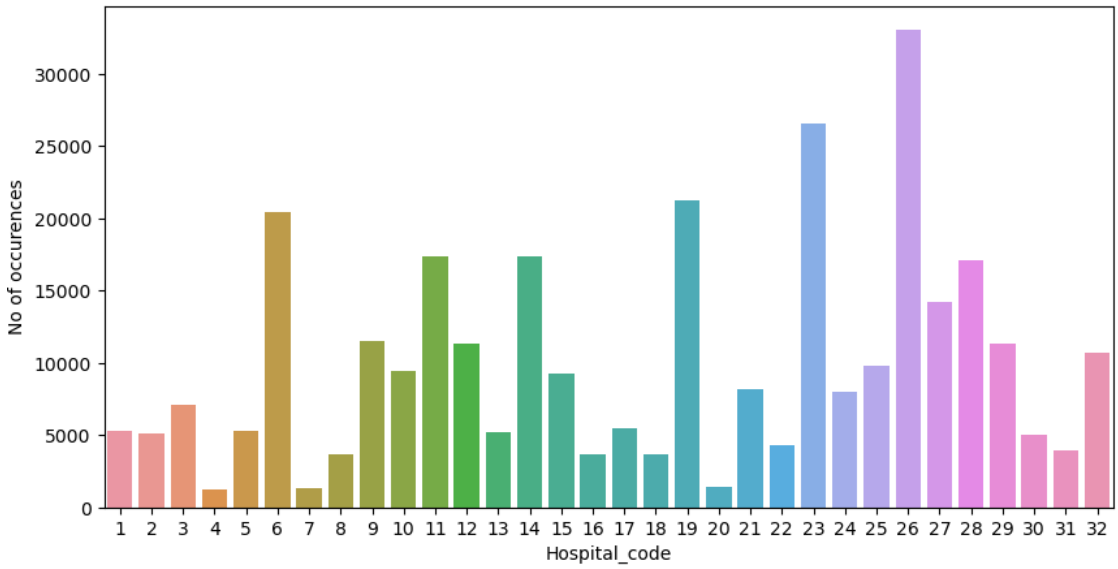

175000
150000
125000
100000
75000
50000
25000
0
No of occurences
Moderate
Minor
Extreme
Severity of Illness

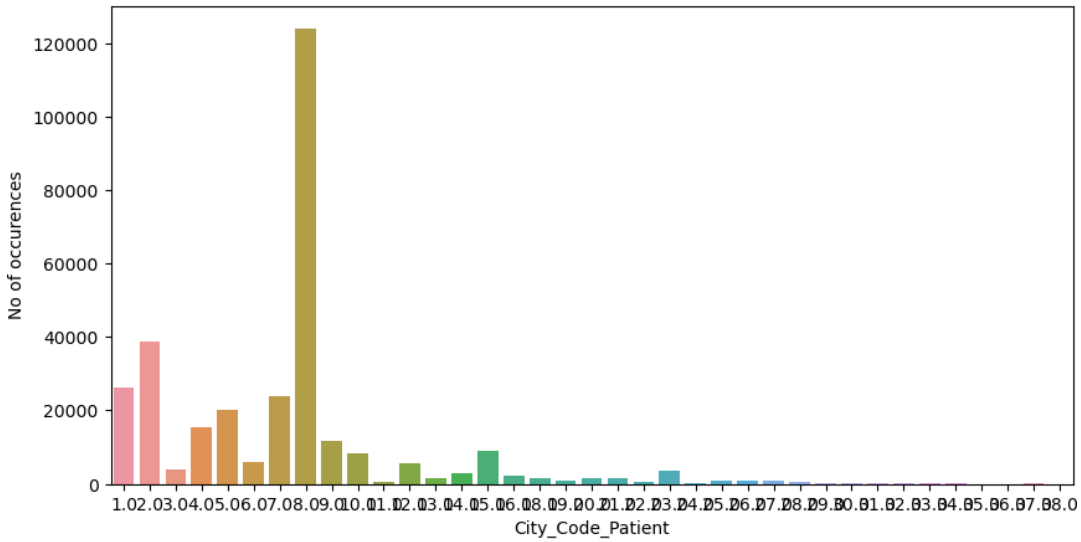

120000
100000
80000
60000
40000
20000
0
No of occurences
1.0
2.0
3.0
4.0
Bed Grade

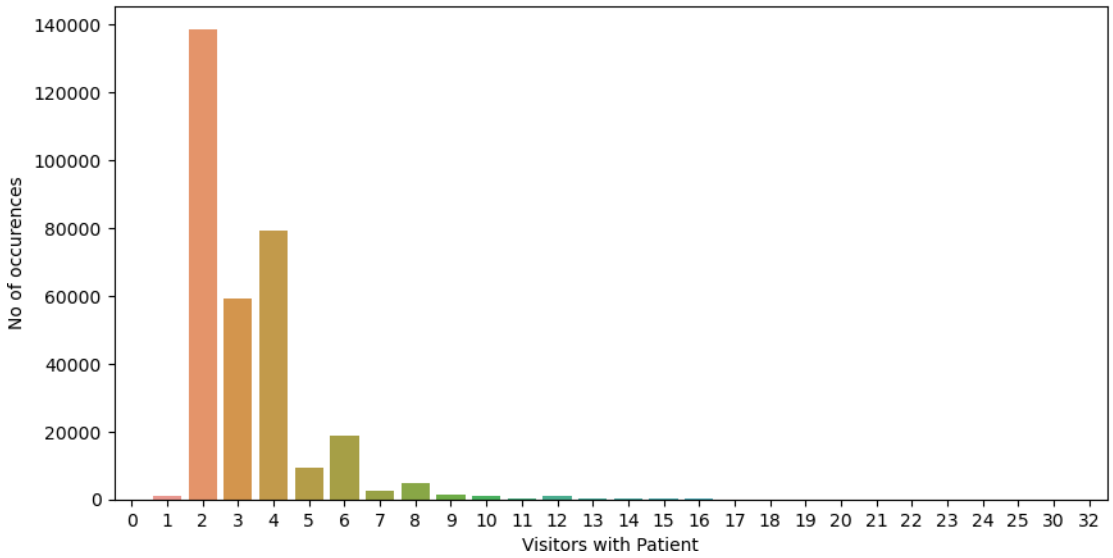

140000
120000
100000
80000
60000
40000
20000
0
No of occurences
X
Y
Z
Hospital_region_code


140000
120000
100000
80000
60000
40000
20000
0
No of occurences
a
b
c
e
d
f
g
Hospital_type_code

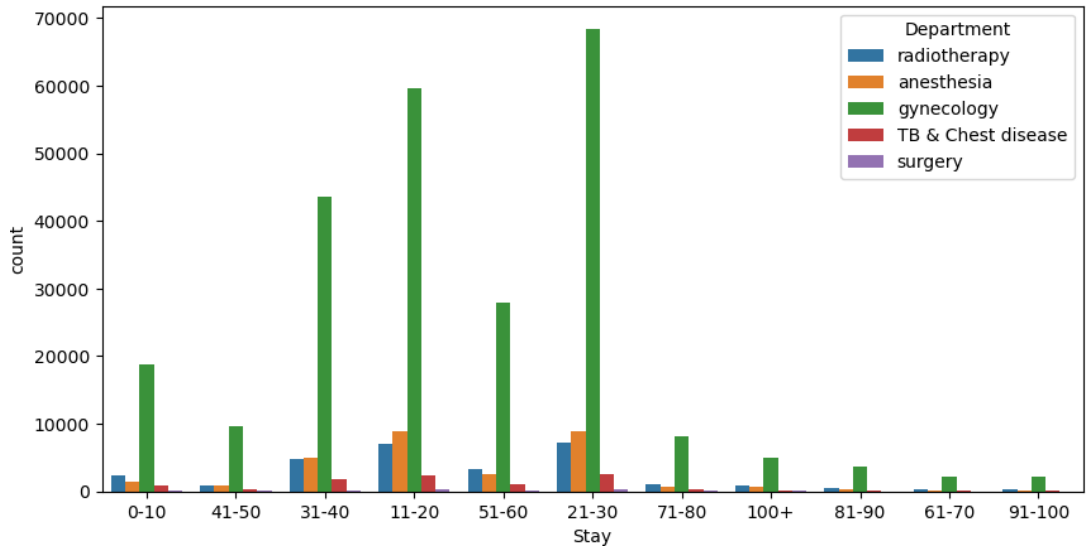

50000
40000
30000
20000
10000
0
No of occurences
1
2
3
4
5
6
7
9
10
11
13
City_Code_Hospital

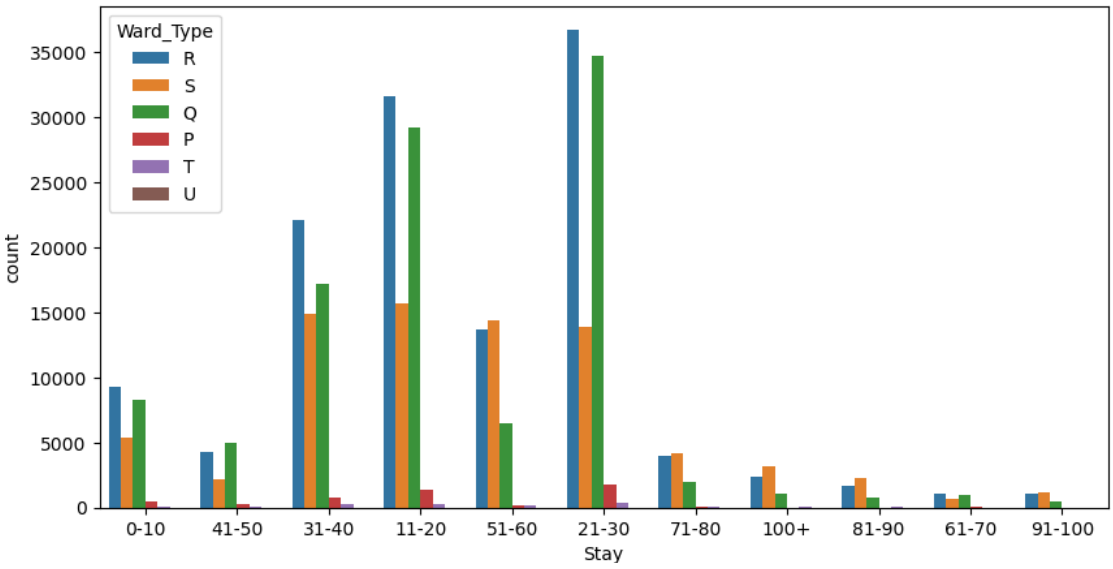

No of occurences
30000
25000
20000
15000
10000
5000
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32
Hospital_code

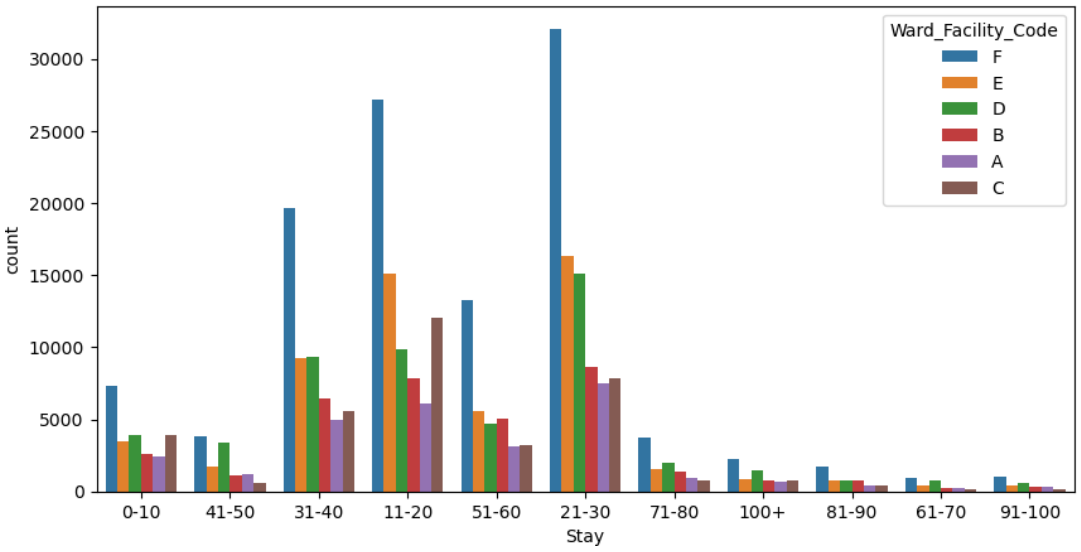

No of occurences
120000
100000
80000
60000
40000
20000
0
City_Code_Patient

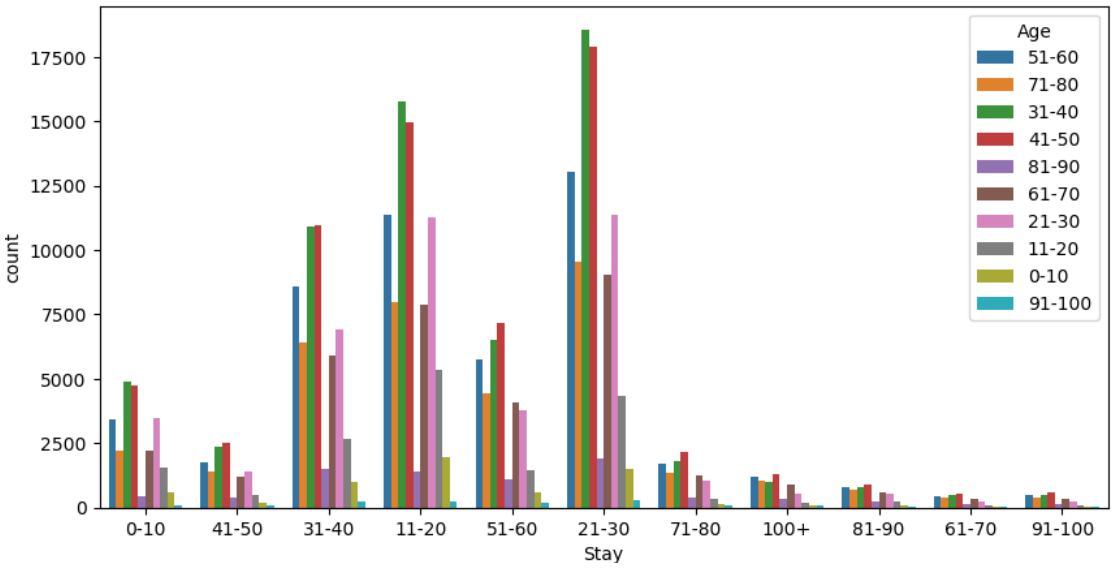


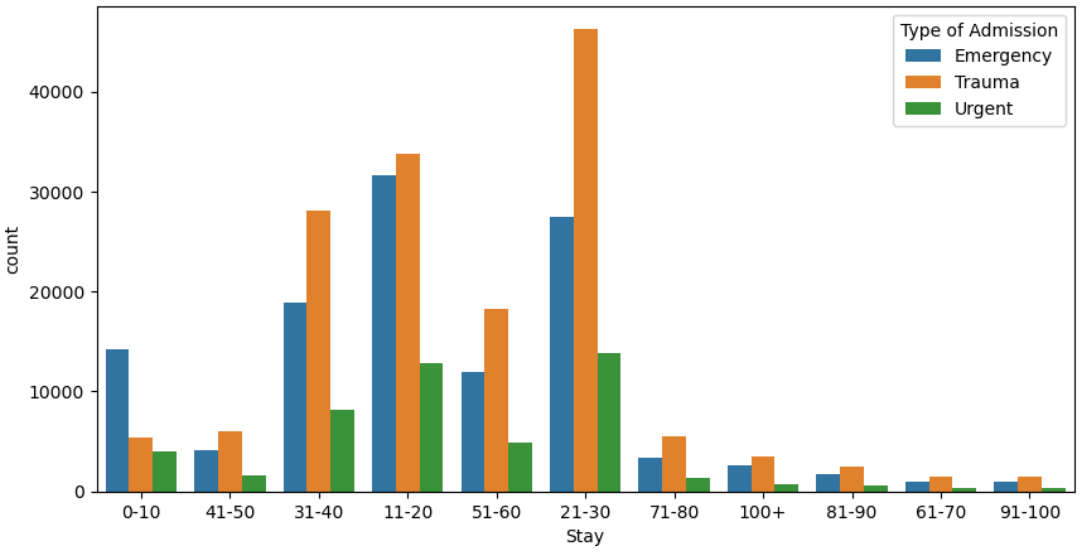

```
for i in [ 'Department', 'Ward_Type' ,'Ward_Facility_Code', 'Age',
'Type of Admission', 'Severity of Illness',
          'Bed Grade', 'Hospital_region_code', 'Hospital_type_code' ]:

            plt.figure(figsize=(10,5))

            sns.countplot(x='Stay',hue=i,data=train)
```

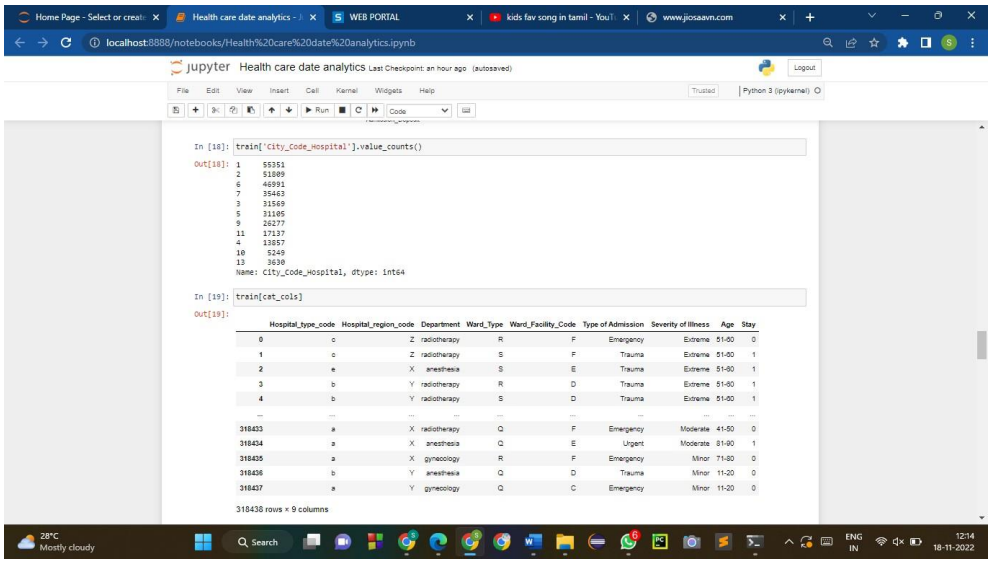


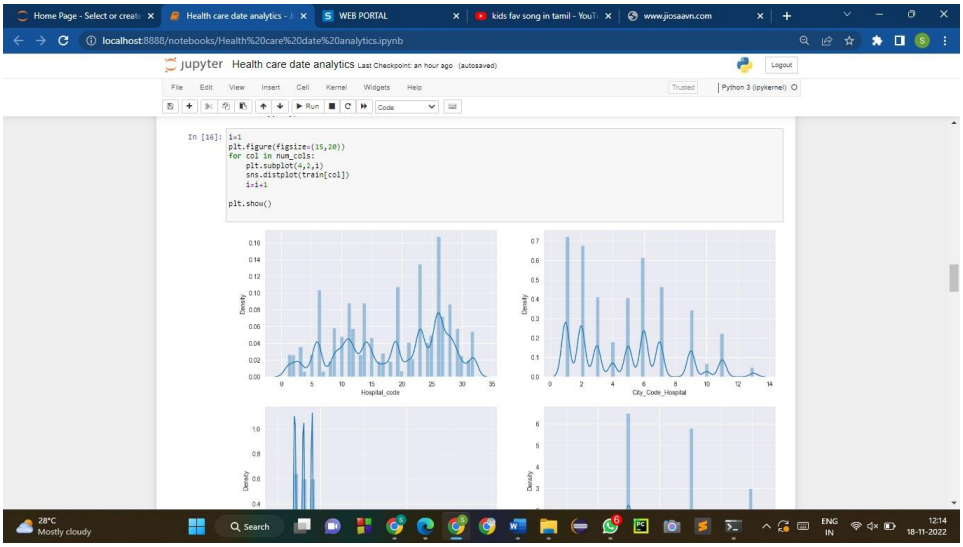

Ward_Type
R
S
Q
P
T
U
count
35000
30000
25000
20000
15000
10000
5000
0
0-10
41-50
31-40
11-20
51-60
21-30
71-80
100+
81-90
61-70
91-100
Stay


Ward_Facility_Code
F
E
D
B
A
C
count
30000
25000
20000
15000
10000
5000
0
0-10
41-50
31-40
11-20
51-60
21-30
71-80
100+
81-90
61-70
91-100
Stay


Age
51-60
71-80
31-40
41-50
81-90
61-70
21-30
11-20
0-10
91-100
count
17500
15000
12500
10000
7500
5000
2500
0
0-10
41-50
31-40
11-20
51-60
21-30
71-80
100+
81-90
61-70
91-100
Stay


Type of Admission
Emergency
Trauma
Urgent
count
40000
30000
20000
10000
0
0-10
41-50
31-40
11-20
51-60
21-30
71-80
100+
81-90
61-70
91-100
Stay


Health care date analytics - J
WEB PORTAL
kids fav song in tamil - YouT
www.jiosaavn.com
localhost:8888/notebooks/Health%20care%20date%20analytics.ipynb
jupyter Health care date analytics Last Checkpoint: an hour ago (autosaved)
Logout
File Edit View Insert Cell Kernel Widgets Help
Trusted
Python 3 (ipykernel)
Run
Code
In [18]: train['City_Code_Hospital'].value_counts()
Out[18]: 1 55351
2 51809
6 46991
7 35463
3 31569
5 31105
9 26277
11 17137
4 13857
10 5249
13 3630
Name: City_Code_Hospital, dtype: int64
In [19]: train[cat_cols]
Out[19]:
Hospital_type_code Hospital_region_code Department Ward_Type Ward_Facility_Code Type of Admission Severity of Illness Age Stay
0 c Z radiotherapy R F Emergency Extreme 51-60 0
1 c Z radiotherapy S F Trauma Extreme 51-60 1
2 e X anesthesia S E Trauma Extreme 51-60 1
3 b Y radiotherapy R D Trauma Extreme 51-60 1
4 b Y radiotherapy S D Trauma Extreme 51-60 1
318433 a X radiotherapy Q F Emergency Moderate 41-50 0
318434 a X anesthesia Q E Urgent Moderate 81-90 1
318435 a X gynecology R F Emergency Minor 71-80 0
318436 b Y anesthesia Q D Trauma Minor 11-20 0
318437 a Y gynecology Q C Emergency Minor 11-20 0
318438 rows × 9 columns
28°C Mostly cloudy
Search
ENG IN
12:14 18-11-2022


Health care date analytics - J
WEB PORTAL
kids fav song in tamil - YouT
www.jiosaavn.com
localhost:8888/notebooks/Health%20care%20date%20analytics.ipynb
jupyter Health care date analytics Last Checkpoint: an hour ago (autosaved)
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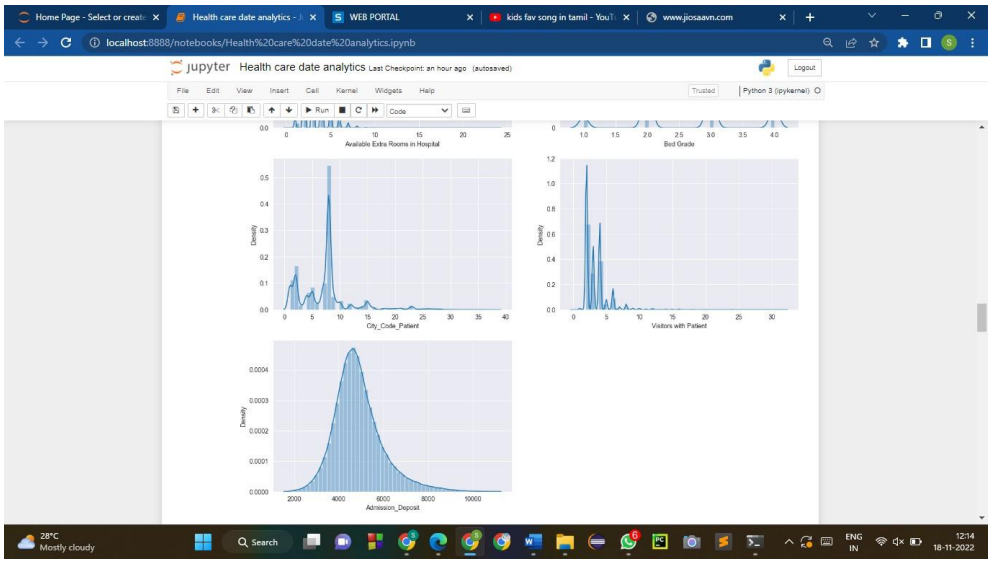
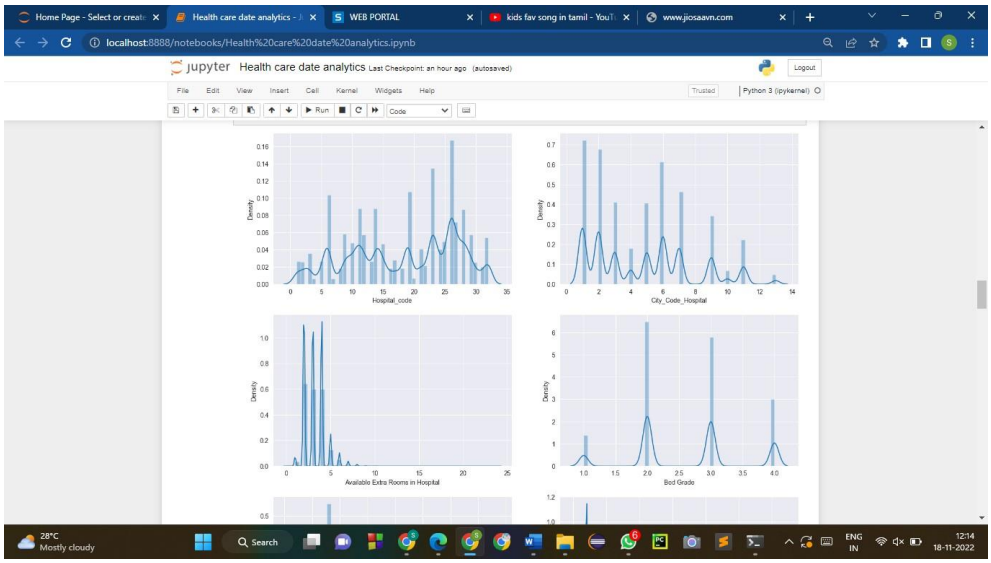
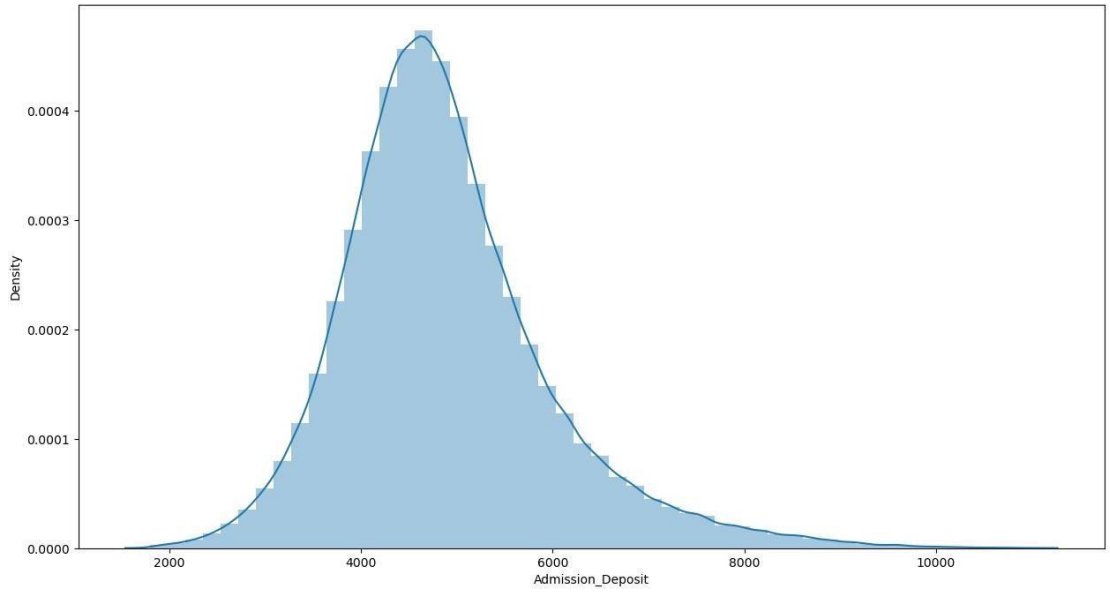
Trusted
Python 3 (ipykernel)
Run
Code
In [16]: i=1
plt.figure(figsize=(15,20))
for col in num_cols:
plt.subplot(4,2,i)
sns.distplot(train[col])
i=i+1
plt.show()
Density
Hospital_code
City_Code_Hospital
28°C Mostly cloudy
Search
ENG IN
12:14 18-11-2022






```
sns.distplot( train['Admission_Deposit'])
```

```
<AxesSubplot:xlabel='Admission_Deposit', ylabel='Density'>
```




```
Total = train.isnull().sum().sort_values(ascending=False)

Percent =
(train.isnull().sum()*100/train.isnull().count()).sort_values(ascendin
g=False)

missing_data = pd.concat([Total, Percent], axis = 1, keys = ['Total',
'Percentage of Missing Values'])
missing_data
```

	Total	Percentage of Missing Values
City_Code_Patient	4532	1.423197
Bed Grade	113	0.035486
Hospital_code	0	0.000000
Hospital_type_code	0	0.000000
City_Code_Hospital	0	0.000000
Hospital_region_code	0	0.000000
Available Extra Rooms in Hospital	0	0.000000
Department	0	0.000000
Ward_Type	0	0.000000
Ward_Facility_Code	0	0.000000
Type of Admission	0	0.000000
Severity of Illness	0	0.000000
Visitors with Patient	0	0.000000
Age	0	0.000000
Admission_Deposit	0	0.000000
Stay	0	0.000000

```
Total = train.isnull().sum().sort_values(ascending=False)

Percent =
(train.isnull().sum()*100/train.isnull().count()).sort_values(ascendin
```

```
g=False)

missing_data = pd.concat([Total, Percent], axis = 1, keys = ['Total',
'Percentage of Missing Values'])
missing_data
```

	Total	Percentage of Missing Values
City_Code_Patient	4532	1.423197
Bed Grade	113	0.035486
Hospital_code	0	0.000000
Hospital_type_code	0	0.000000
City_Code_Hospital	0	0.000000
Hospital_region_code	0	0.000000
Available Extra Rooms in Hospital	0	0.000000
Department	0	0.000000
Ward_Type	0	0.000000
Ward_Facility_Code	0	0.000000
Type of Admission	0	0.000000
Severity of Illness	0	0.000000
Visitors with Patient	0	0.000000
Age	0	0.000000
Admission_Deposit	0	0.000000
Stay	0	0.000000

```
Total = test.isnull().sum().sort_values(ascending=False)

Percent =
(test.isnull().sum()*100/test.isnull().count()).sort_values(ascending=
False)

missing_data = pd.concat([Total, Percent], axis = 1, keys = ['Total',
'Percentage of Missing Values'])
missing_data
```

	Total	Percentage of Missing Values
City_Code_Patient	2157	1.573798
Bed Grade	35	0.025537
Hospital_code	0	0.000000
Hospital_type_code	0	0.000000
City_Code_Hospital	0	0.000000
Hospital_region_code	0	0.000000
Available Extra Rooms in Hospital	0	0.000000
Department	0	0.000000
Ward_Type	0	0.000000
Ward_Facility_Code	0	0.000000
Type of Admission	0	0.000000
Severity of Illness	0	0.000000
Visitors with Patient	0	0.000000
Age	0	0.000000
Admission_Deposit	0	0.000000

```
train.dropna(subset = ['Bed Grade', 'City_Code_Patient'], inplace =
True)

test['Bed Grade'] = test['Bed Grade'].fillna(test['Bed Grade'].mode()
[0], inplace = True)
test['City_Code_Patient'] =
test['City_Code_Patient'].fillna(test['City_Code_Patient'].mode()[0],
inplace = True)

df_num_train = train.select_dtypes([np.number])
df_num_train.head()
```

```
   Visitors with Patient  Admission_Deposit
0                      2        4911.000000
1                      2        5954.000000
2                      2        4745.000000
3                      2        7272.000000
4                      2        5558.000000
```

```
df_cat_train = train.select_dtypes([np.object])
df_cat_train.head()
```

```
  Hospital_code Hospital_type_code City_Code_Hospital
Hospital_region_code \
0              8                  c                  3
Z
1              2                  c                  5
Z
2             10                  e                  1
X
3             26                  b                  2
Y
4             26                  b                  2
Y

  Available Extra  Rooms in Hospital    Department Ward_Type  \
0                                 3  radiotherapy         R
1                                 2  radiotherapy         S
2                                 2    anesthesia         S
3                                 2  radiotherapy         R
4                                 2  radiotherapy         S

  Ward_Facility_Code Bed Grade City_Code_Patient Type of Admission  \
0                  F  2.000000          7.000000         Emergency
1                  F  2.000000          7.000000            Trauma
2                  E  2.000000          7.000000            Trauma
3                  D  2.000000          7.000000            Trauma
4                  D  2.000000          7.000000            Trauma

  Severity of Illness    Age   Stay
0             Extreme  51-60   0-10
```

```
1             Extreme  51-60  41-50
2             Extreme  51-60  31-40
3             Extreme  51-60  41-50
4             Extreme  51-60  41-50
```

```
df_num_test = test.select_dtypes([np.number])
df_num_test.head()
```

```
   Visitors with Patient  Admission_Deposit
0                      2        3095.000000
1                      4        4018.000000
2                      3        4492.000000
3                      3        4173.000000
4                      4        4161.000000
```

```
df_cat_test = test.select_dtypes([np.object])
df_cat_test.head()
```

```
  Hospital_code Hospital_type_code City_Code_Hospital
Hospital_region_code \
0            21                  c                  3
Z
1            29                  a                  4
X
2            26                  b                  2
Y
3             6                  a                  6
X
4            28                  b                 11
X

  Available Extra Rooms in Hospital  Department Ward_Type
Ward_Facility_Code  \
0                                 3  gynecology         S
A
1                                 2  gynecology         S
F
2                                 3  gynecology         Q
D
3                                 3  gynecology         Q
F
4                                 2  gynecology         R
F

  Bed Grade City_Code_Patient Type of Admission Severity of Illness
Age
0      None              None         Emergency            Moderate
71-80
1      None              None            Trauma            Moderate
71-80
2      None              None         Emergency            Moderate
```

```
71-80
3       None                None              Trauma              Moderate
71-80
4       None                None              Trauma              Moderate
71-80

admission_encode = {'Trauma': 1, 'Urgent': 2, 'Emergency' : 3 }
severity_encode   = {'Minor': 1, 'Moderate': 2, 'Extreme': 3 }


df_cat_train['Type of Admission'] = df_cat_train['Type of
Admission'].map (admission_encode)
df_cat_train['Severity of Illness'] = df_cat_train['Severity of
Illness'].map (severity_encode)

df_cat_test['Type of Admission'] = df_cat_test['Type of
Admission'].map (admission_encode)
df_cat_test['Severity of Illness'] = df_cat_test['Severity of
Illness'].map (severity_encode)

df_cat_train['Stay']= df_cat_train['Stay'].replace({'0-10':1, '11-
20':2, '21-30':3, '31-40':4, '41-50':5, '51-60':6,'61-70':7,
                                        '71-80':8,'81-90':9,'91-
100':10,'100+':11})

df_cat_train['Age']= df_cat_train['Age'].replace({'0-10':1, '11-20':2,
'21-30':3, '31-40':4, '41-50':5, '51-60':6,'61-70':7,
                                        '71-80':8,'81-90':9,'91-
100':10})

df_cat_test['Age']= df_cat_test['Age'].replace({'0-10':1, '11-20':2,
'21-30':3, '31-40':4, '41-50':5, '51-60':6,'61-70':7,
                                        '71-80':8,'81-90':9,'91-
100':10})

df_cat_train['Stay']=df_cat_train['Stay'].astype(int)

from sklearn.preprocessing import LabelEncoder
LE=LabelEncoder()

df_cat_train['Hospital_code']=LE.fit_transform(df_cat_train['Hospital_
code'])
df_cat_train['Hospital_type_code']=LE.fit_transform(df_cat_train['Hosp
ital_type_code'])
df_cat_train['City_Code_Hospital']=LE.fit_transform(df_cat_train['City
_Code_Hospital'])
df_cat_train['Hospital_region_code']=LE.fit_transform(df_cat_train['Ho
spital_region_code'])
df_cat_train['Department']=LE.fit_transform(df_cat_train['Department']
)
```

```
df_cat_train['Ward_Type']=LE.fit_transform(df_cat_train['Ward_Type'])
df_cat_train['Ward_Facility_Code']=LE.fit_transform(df_cat_train['Ward
_Facility_Code'])
df_cat_train['City_Code_Patient']=LE.fit_transform(df_cat_train['City_
Code_Patient'])
df_cat_train['Bed Grade']=LE.fit_transform(df_cat_train['Bed Grade'])

df_cat_train.head()
```

```
   Hospital_code  Hospital_type_code  City_Code_Hospital  \
0              7                   2                   2
1              1                   2                   4
2              9                   4                   0
3             25                   1                   1
4             25                   1                   1

   Hospital_region_code Available Extra Rooms in Hospital  Department
\
0                     2                                3           3

1                     2                                2           3

2                     0                                2           1

3                     1                                2           3

4                     1                                2           3


   Ward_Type  Ward_Facility_Code  Bed Grade  City_Code_Patient  \
0          2                   5          1                  6
1          3                   5          1                  6
2          3                   4          1                  6
3          2                   3          1                  6
4          3                   3          1                  6

   Type of Admission  Severity of Illness  Age  Stay
0                  3                    3    6     1
1                  1                    3    6     5
2                  1                    3    6     4
3                  1                    3    6     5
4                  1                    3    6     5
```

```
from sklearn.preprocessing import LabelEncoder
LE=LabelEncoder()

df_cat_test['Hospital_code']=LE.fit_transform(df_cat_test['Hospital_co
de'])
df_cat_test['Hospital_type_code']=LE.fit_transform(df_cat_test['Hospit
al_type_code'])
```

```
df_cat_test['City_Code_Hospital']=LE.fit_transform(df_cat_test['City_Code_Hospital'])
df_cat_test['Hospital_region_code']=LE.fit_transform(df_cat_test['Hospital_region_code'])
df_cat_test['Department']=LE.fit_transform(df_cat_test['Department'])
df_cat_test['Ward_Type']=LE.fit_transform(df_cat_test['Ward_Type'])
df_cat_test['Ward_Facility_Code']=LE.fit_transform(df_cat_test['Ward_Facility_Code'])
df_cat_test['City_Code_Patient']=LE.fit_transform(df_cat_test['City_Code_Patient'])
df_cat_test['Bed Grade']=LE.fit_transform(df_cat_test['Bed Grade'])

df_cat_test.head()
```

```
   Hospital_code  Hospital_type_code  City_Code_Hospital  \
0             20                   2                   2
1             28                   0                   3
2             25                   1                   1
3              5                   0                   5
4             27                   1                   9

   Hospital_region_code Available Extra Rooms in Hospital  Department
\
0                     2                                 3           2

1                     0                                 2           2

2                     1                                 3           2

3                     0                                 3           2

4                     0                                 2           2


   Ward_Type  Ward_Facility_Code  Bed Grade  City_Code_Patient  \
0          3                   0          0                  0
1          3                   5          0                  0
2          1                   3          0                  0
3          1                   5          0                  0
4          2                   5          0                  0

   Type of Admission  Severity of Illness  Age
0                  3                    2    8
1                  1                    2    8
2                  3                    2    8
3                  1                    2    8
4                  1                    2    8
```

```
from sklearn.preprocessing import StandardScaler
sc = StandardScaler()
```

```
num_scaled = sc.fit_transform(df_num_train)

df_num_scaled = pd.DataFrame(num_scaled, columns =
df_num_train.columns)


num_scaled_test = sc.fit_transform(df_num_test)

df_num_scaled_test = pd.DataFrame(num_scaled_test, columns =
df_num_test.columns)

df_num_scaled.shape
```

```
(313793, 2)
```

```
df_cat_train = df_cat_train.reset_index(drop=True)
df_num_scaled = df_num_scaled.reset_index(drop=True)
df_cat_test = df_cat_test.reset_index(drop=True)
df_num_scaled_test = df_num_scaled_test.reset_index(drop=True)

df_cat_train.shape
```

```
(313793, 14)
```

```
df_full = pd.concat([df_num_scaled, df_cat_train],axis=1)
df_full_test =  pd.concat([df_num_scaled_test, df_cat_test],axis=1)

df_full.shape
```

```
(313793, 16)
```

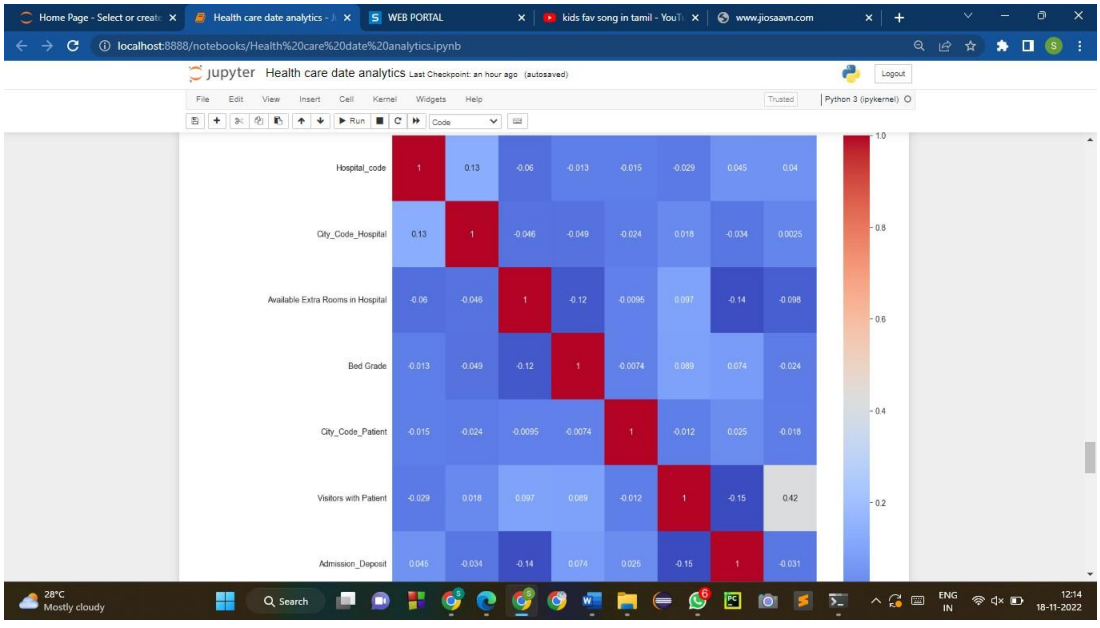
```
df_full.head()
```

```
   Visitors with Patient  Admission_Deposit  Hospital_code  \
0              -0.727035           0.026796              7
1              -0.727035           0.986987              1
2              -0.727035          -0.126025              9
3              -0.727035           2.200344             25
4              -0.727035           0.622427             25

   Hospital_type_code  City_Code_Hospital  Hospital_region_code  \
0                   2                   2                     2
1                   2                   4                     2
2                   4                   0                     0
3                   1                   1                     1
4                   1                   1                     1

  Available Extra Rooms in Hospital  Department  Ward_Type  \
0                                 3           3          2
1                                 2           3          3
2                                 2           1          3
```

```
3                                    2                3                2
4                                    2                3                3

   Ward_Facility_Code  Bed Grade  City_Code_Patient  Type of Admission
\
0                   5          1                  6                  3

1                   5          1                  6                  1

2                   4          1                  6                  1

3                   3          1                  6                  1

4                   3          1                  6                  1


   Severity of Illness  Age  Stay
0                    3    6     1
1                    3    6     5
2                    3    6     4
3                    3    6     5
4                    3    6     5
```

```
sns.heatmap(df_full.corr(), annot = True)
```

```
<AxesSubplot:>
```



```
X = df_full.drop('Stay',axis=1)
y = df_full['Stay']

X = sm.add_constant(X)

X_train, X_test, y_train, y_test = train_test_split(X, y, random_state
= 10, test_size = 0.3)

print('X_train', X_train.shape)
print('y_train', y_train.shape)

print('X_test', X_test.shape)
print('y_test', y_test.shape)
```

```
X_train (219655, 16)
y_train (219655,)
X_test (94138, 16)
y_test (94138,)
```

```
from sklearn.model_selection import KFold,cross_val_score
kfold=KFold(n_splits=10, shuffle=True, random_state=10)

LR = LogisticRegression()

LR.fit(X_train,y_train)

y_pred_LR=LR.predict(X_test)
accuracy_score(y_test,y_pred_LR)*100
```

```
37.94217000573626
```

```
print(classification_report(y_test,y_pred_LR))
```

```
              precision    recall  f1-score   support

           1       0.48      0.02      0.03      6901
           2       0.37      0.45      0.41     23205
           3       0.40      0.64      0.49     25792
           4       0.32      0.19      0.24     16289
           5       0.00      0.00      0.00      3439
           6       0.37      0.46      0.41     10470
           7       0.00      0.00      0.00       822
           8       0.00      0.00      0.00      3093
           9       0.11      0.00      0.01      1412
          10       0.00      0.00      0.00       782
          11       0.49      0.32      0.39      1933

    accuracy                           0.38     94138
   macro avg       0.23      0.19      0.18     94138
weighted avg       0.34      0.38      0.33     94138
```

```
decision_tree_classification = DecisionTreeClassifier(criterion =
'entropy', random_state = 10)

decision_tree = decision_tree_classification.fit(X_train, y_train)

y_pred_DT=decision_tree.predict(X_test)
accuracy_score(y_test,y_pred_DT)*100
```

```
29.678769466102956
```

```
print(classification_report(y_test,y_pred_DT))
```

```
              precision    recall  f1-score   support

           1       0.19      0.19      0.19      6901
           2       0.34      0.34      0.34     23205
           3       0.39      0.38      0.38     25792
           4       0.25      0.25      0.25     16289
           5       0.06      0.07      0.07      3439
           6       0.31      0.30      0.31     10470
           7       0.03      0.04      0.03       822
           8       0.15      0.15      0.15      3093
           9       0.22      0.23      0.22      1412
          10       0.08      0.10      0.09       782
          11       0.32      0.35      0.33      1933

    accuracy                           0.30     94138
   macro avg       0.21      0.22      0.21     94138
weighted avg       0.30      0.30      0.30     94138
```

```
dt_tuned = DecisionTreeClassifier(criterion = 'gini', max_depth=11,
random_state = 10)

decision_tree_tuned = dt_tuned.fit(X_train, y_train)

y_pred_DT_tuned = decision_tree_tuned.predict(X_test)
accuracy_score(y_test,y_pred_DT_tuned)*100
```

```
40.82198474579872
```

```
print(classification_report(y_test,y_pred_DT_tuned))
```

```
              precision    recall  f1-score   support

           1       0.36      0.13      0.19      6901
           2       0.41      0.46      0.44     23205
           3       0.41      0.67      0.51     25792
           4       0.39      0.23      0.29     16289
           5       0.07      0.00      0.00      3439
           6       0.41      0.45      0.43     10470
           7       0.00      0.00      0.00       822
```

```
           8       0.27      0.03      0.05      3093
           9       0.35      0.21      0.27      1412
          10       0.20      0.03      0.05       782
          11       0.52      0.36      0.43      1933

    accuracy                           0.41     94138
   macro avg       0.31      0.23      0.24     94138
weighted avg       0.38      0.41      0.37     94138
```

```
rf_classification = RandomForestClassifier(random_state = 10)

rf_model = rf_classification.fit(X_train, y_train)

y_pred_RF = rf_model.predict(X_test)
accuracy_score(y_test,y_pred_RF)*100
```

```
38.315026875438186
```

```
print(classification_report(y_test,y_pred_RF))
```

```
              precision    recall  f1-score   support

           1       0.30      0.19      0.23      6901
           2       0.39      0.44      0.42     23205
           3       0.41      0.54      0.47     25792
           4       0.33      0.27      0.29     16289
           5       0.09      0.02      0.04      3439
           6       0.40      0.44      0.42     10470
           7       0.10      0.02      0.03       822
           8       0.28      0.10      0.15      3093
           9       0.37      0.22      0.28      1412
          10       0.24      0.06      0.09       782
          11       0.52      0.44      0.48      1933

    accuracy                           0.38     94138
   macro avg       0.31      0.25      0.26     94138
weighted avg       0.36      0.38      0.37     94138
```

```
rf_classification_tuned = RandomForestClassifier(criterion = 'gini',
n_estimators = 47, random_state = 10)

rf_model_tuned = rf_classification_tuned.fit(X_train, y_train)

y_pred_RF_tuned = rf_model_tuned.predict(X_test)
accuracy_score(y_test,y_pred_RF_tuned)*100
```

```
37.94323227602031
```

```
print(classification_report(y_test,y_pred_RF_tuned))
```

```
                precision    recall  f1-score   support

             1       0.29      0.19      0.23      6901
             2       0.38      0.44      0.41     23205
             3       0.41      0.53      0.46     25792
             4       0.32      0.27      0.30     16289
             5       0.09      0.02      0.04      3439
             6       0.39      0.43      0.41     10470
             7       0.10      0.02      0.03       822
             8       0.28      0.11      0.15      3093
             9       0.36      0.22      0.27      1412
            10       0.22      0.05      0.08       782
            11       0.52      0.43      0.47      1933

    accuracy                           0.38     94138
   macro avg       0.31      0.25      0.26     94138
weighted avg       0.36      0.38      0.36     94138
```

```
dt_tuned = DecisionTreeClassifier(criterion = 'gini', max_depth=11,
random_state = 10)
ada_model_DT = AdaBoostClassifier(base_estimator=dt_tuned,
random_state = 10)

ada_model_DT.fit(X_train, y_train)

AdaBoostClassifier(base_estimator=DecisionTreeClassifier(max_depth=11,

random_state=10),
                   random_state=10)

y_pred_ada_model_DT = ada_model_DT.predict(X_test)
accuracy_score(y_test,y_pred_ada_model_DT)*100

29.91990482058255

print(classification_report(y_test,y_pred_ada_model_DT))
```

```
                precision    recall  f1-score   support

             1       0.19      0.16      0.17      6901
             2       0.33      0.34      0.33     23205
             3       0.38      0.39      0.39     25792
             4       0.22      0.27      0.24     16289
             5       0.06      0.04      0.05      3439
             6       0.31      0.36      0.33     10470
             7       0.00      0.00      0.00       822
             8       0.14      0.10      0.11      3093
             9       0.22      0.10      0.13      1412
            10       0.10      0.01      0.02       782
            11       0.45      0.20      0.27      1933
```

```
    accuracy                           0.30     94138
   macro avg       0.22      0.18      0.19     94138
weighted avg       0.29      0.30      0.29     94138
```

```
ada_model_DT_tuned = AdaBoostClassifier(base_estimator=dt_tuned,
n_estimators = 1, random_state = 10)

ada_model_DT_tuned.fit(X_train, y_train)

AdaBoostClassifier(base_estimator=DecisionTreeClassifier(max_depth=11,

random_state=10),
                   n_estimators=1, random_state=10)

y_pred_ada_model_DT_tuned = ada_model_DT.predict(X_test)
accuracy_score(y_test,y_pred_ada_model_DT_tuned)*100

29.91990482058255

print(classification_report(y_test,y_pred_ada_model_DT_tuned))
```

```
              precision    recall  f1-score   support

           1       0.19      0.16      0.17      6901
           2       0.33      0.34      0.33     23205
           3       0.38      0.39      0.39     25792
           4       0.22      0.27      0.24     16289
           5       0.06      0.04      0.05      3439
           6       0.31      0.36      0.33     10470
           7       0.00      0.00      0.00       822
           8       0.14      0.10      0.11      3093
           9       0.22      0.10      0.13      1412
          10       0.10      0.01      0.02       782
          11       0.45      0.20      0.27      1933

    accuracy                           0.30     94138
   macro avg       0.22      0.18      0.19     94138
weighted avg       0.29      0.30      0.29     94138
```

```
rf_classification_tuned = RandomForestClassifier(criterion = 'gini',
n_estimators = 47, random_state = 10)

ada_model_rf =
AdaBoostClassifier(base_estimator=rf_classification_tuned,
n_estimators=1, random_state = 10)

ada_model_rf.fit(X_train, y_train)
```

```
AdaBoostClassifier(base_estimator=RandomForestClassifier(n_estimators=
47,

random_state=10),
                   n_estimators=1, random_state=10)

y_pred_ada_model_RF = ada_model_rf.predict(X_test)
accuracy_score(y_test,y_pred_ada_model_RF)*100

38.081327412946955

print(classification_report(y_test,y_pred_ada_model_RF))

              precision    recall  f1-score   support

           1       0.29      0.20      0.23      6901
           2       0.39      0.44      0.41     23205
           3       0.41      0.53      0.46     25792
           4       0.32      0.27      0.30     16289
           5       0.10      0.03      0.04      3439
           6       0.40      0.43      0.41     10470
           7       0.12      0.02      0.03       822
           8       0.26      0.10      0.15      3093
           9       0.39      0.24      0.29      1412
          10       0.23      0.05      0.09       782
          11       0.51      0.44      0.47      1933

    accuracy                           0.38     94138
   macro avg       0.31      0.25      0.26     94138
weighted avg       0.36      0.38      0.36     94138


ada_model_rf_tuned =
AdaBoostClassifier(base_estimator=rf_classification_tuned,
n_estimators = 4, random_state = 10)

ada_model_rf_tuned.fit(X_train, y_train)

AdaBoostClassifier(base_estimator=RandomForestClassifier(n_estimators=
47,

random_state=10),
                   n_estimators=4, random_state=10)

from sklearn.ensemble import GradientBoostingClassifier
GB=GradientBoostingClassifier(random_state=10)
GB.fit(X_train, y_train)

GradientBoostingClassifier(random_state=10)

y_pred_GB = GB.predict(X_test)
accuracy_score(y_test,y_pred_GB)*100
```

```
41.5475153498056
```

```
print(classification_report(y_test,y_pred_GB))
```

```
              precision    recall  f1-score   support

           1       0.41      0.12      0.19      6901
           2       0.42      0.51      0.46     23205
           3       0.42      0.66      0.52     25792
           4       0.41      0.17      0.24     16289
           5       0.14      0.00      0.00      3439
           6       0.39      0.53      0.45     10470
           7       0.00      0.00      0.00       822
           8       0.30      0.01      0.02      3093
           9       0.31      0.20      0.24      1412
          10       0.17      0.01      0.01       782
          11       0.52      0.40      0.45      1933

    accuracy                           0.42     94138
   macro avg       0.32      0.24      0.23     94138
weighted avg       0.39      0.42      0.37     94138
```

```
GB_tuned=GradientBoostingClassifier(n_estimators=29, random_state=10)
GB_tuned.fit(X_train, y_train)
```

```
GradientBoostingClassifier(n_estimators=29, random_state=10)
```

```
from sklearn.naive_bayes import GaussianNB
NB = GaussianNB()
NB.fit(X_train,y_train)
```

```
GaussianNB()
```

```
y_pred_NB = NB.predict(X_test)
accuracy_score(y_test,y_pred_NB)*100
```

```
36.37850814761308
```

```
print(classification_report(y_test,y_pred_NB))
```

```
              precision    recall  f1-score   support

           1       0.30      0.09      0.14      6901
           2       0.36      0.41      0.39     23205
           3       0.39      0.65      0.49     25792
           4       0.32      0.15      0.21     16289
           5       0.08      0.01      0.01      3439
           6       0.33      0.38      0.36     10470
           7       0.04      0.00      0.00       822
           8       0.10      0.01      0.02      3093
           9       0.12      0.02      0.04      1412
```

```
          10       0.50      0.00      0.00       782
          11       0.42      0.37      0.39      1933

    accuracy                           0.36     94138
   macro avg       0.27      0.19      0.18     94138
weighted avg       0.33      0.36      0.32     94138
```

```
from sklearn.neighbors import KNeighborsClassifier

knn=KNeighborsClassifier(n_neighbors=565,weights='distance')
knn.fit(X_train,y_train)
```

```
KNeighborsClassifier(n_neighbors=565, weights='distance')
```

```
y_pred_KNN = NB.predict(X_test)
accuracy_score(y_test,y_pred_KNN)*100
```

```
36.37850814761308
```

```
print(classification_report(y_test,y_pred_NB))
```

```
              precision    recall  f1-score   support

           1       0.30      0.09      0.14      6901
           2       0.36      0.41      0.39     23205
           3       0.39      0.65      0.49     25792
           4       0.32      0.15      0.21     16289
           5       0.08      0.01      0.01      3439
           6       0.33      0.38      0.36     10470
           7       0.04      0.00      0.00       822
           8       0.10      0.01      0.02      3093
           9       0.12      0.02      0.04      1412
          10       0.50      0.00      0.00       782
          11       0.42      0.37      0.39      1933

    accuracy                           0.36     94138
   macro avg       0.27      0.19      0.18     94138
weighted avg       0.33      0.36      0.32     94138
```

```
from catboost import CatBoostClassifier

cb =
CatBoostClassifier(random_state=10,use_best_model=True,iterations=1000
)
cb.fit(X_train,y_train,use_best_model=True,verbose=100,eval_set=(X_tes
t,y_test))
```

```
Learning rate set to 0.120271
0:    learn: 2.1972797test: 2.1978440  best: 2.1978440 (0)    total:
```

```
532ms remaining: 8m 50s
100:  learn: 1.5115382 test: 1.5242638  best: 1.5242638 (100) total:
37.5s remaining: 5m 34s
200:  learn: 1.4818453 test: 1.5070444  best: 1.5070444 (200) total: 1m
17s   remaining: 5m 9s
300:  learn: 1.4638516 test: 1.5016071  best: 1.5016071 (300) total: 1m
57s   remaining: 4m 32s
400:  learn: 1.4484799 test: 1.4983697  best: 1.4983697 (400) total: 2m
35s   remaining: 3m 52s
500:  learn: 1.4345747 test: 1.4970449  best: 1.4970449 (500) total: 3m
14s   remaining: 3m 13s
600:  learn: 1.4237650 test: 1.4965192  best: 1.4964737 (579) total: 3m
56s   remaining: 2m 37s
700:  learn: 1.4123374 test: 1.4963260  best: 1.4961744 (652) total: 4m
34s   remaining: 1m 57s
800:  learn: 1.4018164 test: 1.4964416  best: 1.4961744 (652) total: 5m
13s   remaining: 1m 17s
900:  learn: 1.3915056 test: 1.4967396  best: 1.4961744 (652) total: 5m
52s   remaining: 38.8s
999:  learn: 1.3815565 test: 1.4971529  best: 1.4961744 (652) total: 6m
37s   remaining: 0us

bestTest = 1.496174357
bestIteration = 652

Shrink model to first 653 iterations.

<catboost.core.CatBoostClassifier at 0x1f1be732bb0>
```

```
cb_pred = cb.predict(X_test)
accuracy_score(y_test,cb_pred)*100
```

```
42.54180033567741
```

```
print(classification_report(y_test,cb_pred))
```

```
              precision    recall  f1-score   support

           1       0.41      0.16      0.23      6901
           2       0.43      0.51      0.47     23205
           3       0.43      0.66      0.52     25792
           4       0.41      0.24      0.30     16289
           5       0.24      0.00      0.01      3439
           6       0.41      0.48      0.44     10470
           7       0.12      0.00      0.00       822
           8       0.42      0.03      0.05      3093
           9       0.36      0.21      0.27      1412
          10       0.29      0.01      0.02       782
          11       0.52      0.43      0.47      1933

    accuracy                           0.43     94138
```

```
   macro avg       0.37      0.25      0.25     94138
weighted avg       0.41      0.43      0.39     94138
```

```
cb_pred_train= cb.predict(X_train)
accuracy_score(y_train,cb_pred_train)*100
```

```
45.57692745441715
```

```
print(classification_report(y_train,cb_pred_train))
```

```
              precision    recall  f1-score   support

           1       0.46      0.19      0.27     16349
           2       0.45      0.54      0.49     53890
           3       0.45      0.68      0.54     60524
           4       0.47      0.26      0.34     38023
           5       0.63      0.01      0.02      8102
           6       0.45      0.53      0.48     23993
           7       0.79      0.01      0.02      1876
           8       0.71      0.06      0.10      7003
           9       0.55      0.31      0.40      3349
          10       0.84      0.07      0.12      1931
          11       0.62      0.51      0.56      4615

    accuracy                           0.46    219655
   macro avg       0.58      0.29      0.30    219655
weighted avg       0.48      0.46      0.42    219655
```

```
ls  =  df_full_test.columns.tolist()

in_data = df_full_test[ls]

out_data =  cb.predict (in_data)

test = pd.read_csv("D:/HealthCare/test_data.csv")
submit = pd.DataFrame()

submit ['case_id']  =  test['case_id']
submit ['Stay']     =  out_data

stay_decode         =  {  1 : '0-10', 2 : '11-20', 3 : '21-30', 4 :
'31-40', 5 : '41-50', 6 : '51-60', 7 : '61-70',8 : '71-80', 9 : '81-
90',
                          10 : '91-100', 11 : 'More than 100 Days' }

submit ['Stay']     = submit ['Stay'].map(stay_decode)

submit.head(15)
```

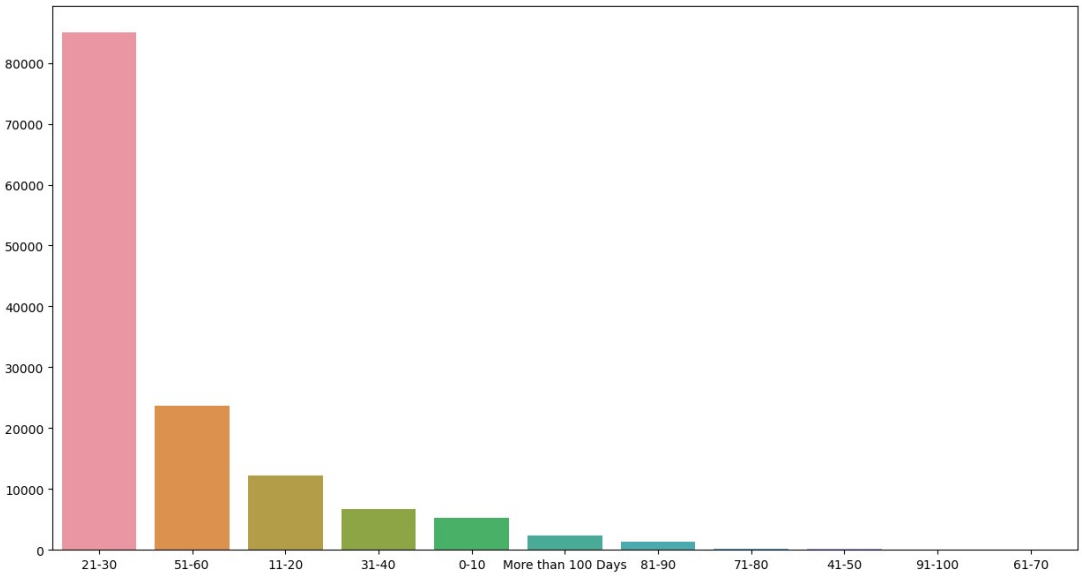
```
    case_id   Stay
0    318439   0-10
1    318440  51-60
2    318441  21-30
3    318442  21-30
4    318443  51-60
5    318444  21-30
6    318445  21-30
7    318446  21-30
8    318447  21-30
9    318448  21-30
10   318449  21-30
11   318450  51-60
12   318451  21-30
13   318452  21-30
14   318453  31-40
```

```
count = submit ['Stay'].value_counts()
count
```

```
21-30                 85076
51-60                 23685
11-20                 12285
31-40                  6693
0-10                   5242
More than 100 Days     2407
81-90                  1329
71-80                   174
41-50                   127
91-100                   32
61-70                     7
Name: Stay, dtype: int64
```

```
sns.barplot(x=count.index.values, y=count.values,data=submit)
```

```
<AxesSubplot:>
```


80000
70000
60000
50000
40000
30000
20000
10000
0
21-30
51-60
11-20
31-40
0-10
More than 100 Days
81-90
71-80
41-50
91-100
61-70