```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
import sklearn as sk
from sklearn.preprocessing import LabelEncoder
from sklearn.impute import SimpleImputer
from sklearn.preprocessing import StandardScaler
from sklearn import metrics



import os
os.environ['OMP_NUM_THREADS']='1'


from google.colab import drive
drive.mount('/content/drive/')
```

```
     Mounted at /content/drive/
```

```
fileName = '/content/drive/MyDrive/Step Up Data Set.csv'


data = pd.read_csv(fileName)


data.info()
```

```
     <class 'pandas.core.frame.DataFrame'>
     RangeIndex: 7043 entries, 0 to 7042
     Data columns (total 21 columns):
      #   Column            Non-Null Count  Dtype
     ---  ------            --------------  -----
      0   customerID        7043 non-null   object
      1   gender            7043 non-null   object
      2   SeniorCitizen     7043 non-null   int64
      3   Partner           7043 non-null   object
      4   Dependents        7043 non-null   object
      5   tenure            7043 non-null   int64
      6   PhoneService      7043 non-null   object
      7   MultipleLines     7043 non-null   object
      8   InternetService   7043 non-null   object
      9   OnlineSecurity    7043 non-null   object
      10  OnlineBackup      7043 non-null   object
      11  DeviceProtection  7043 non-null   object
```

```
 12  TechSupport       7043 non-null   object
 13  StreamingTV       7043 non-null   object
 14  StreamingMovies   7043 non-null   object
 15  Contract          7043 non-null   object
 16  PaperlessBilling  7043 non-null   object
 17  PaymentMethod     7043 non-null   object
 18  MonthlyCharges    7043 non-null   float64
 19  TotalCharges      7043 non-null   object
 20  Churn             7043 non-null   object
dtypes: float64(1), int64(2), object(18)
memory usage: 1.1+ MB
```

```
# Convert total charges to float
# The null values are converting to nan
data.isna().sum()
```

```
customerID          0
gender              0
SeniorCitizen       0
Partner             0
Dependents          0
tenure              0
PhoneService        0
MultipleLines       0
InternetService     0
OnlineSecurity      0
OnlineBackup        0
DeviceProtection    0
TechSupport         0
StreamingTV         0
StreamingMovies     0
Contract            0
PaperlessBilling    0
PaymentMethod       0
MonthlyCharges      0
TotalCharges        0
Churn               0
dtype: int64
```

```
# convert total charges to float
data['TotalCharges'] = pd.to_numeric(data['TotalCharges'], errors='coerce')

# identify the values that could not be converted
invalid_values = data[data['TotalCharges'].isna()]['TotalCharges']

#print(data2)
print("Invalid values:", invalid_values)
```

```
Invalid values: 488    NaN
753    NaN
936    NaN
1082   NaN
1340   NaN
3331   NaN
3826   NaN
4380   NaN
5218   NaN
6670   NaN
6754   NaN
Name: TotalCharges, dtype: float64
```

```
data.head()
```

	customerID	gender	SeniorCitizen	Partner	Dependents	tenure	PhoneService	Multipl
0	7590-VHVEG	Female	0	Yes	No	1	No	No
1	5575-GNVDE	Male	0	No	No	34	Yes	
2	3668-QPYBK	Male	0	No	No	2	Yes	
3	7795-CFOCW	Male	0	No	No	45	No	No
4	9237-HQITU	Female	0	No	No	2	Yes	

5 rows × 21 columns

```
data.describe()
```

	SeniorCitizen	tenure	MonthlyCharges	TotalCharges
count	7043.000000	7043.000000	7043.000000	7032.000000

```
data2 = data
```

std	0.368612	24.559481	30.090047	2266.771362

```
data.tail()
```

	customerID	gender	SeniorCitizen	Partner	Dependents	tenure	PhoneService	Mult
7038	6840-RESVB	Male	0	Yes	Yes	24	Yes	
7039	2234-XADUH	Female	0	Yes	Yes	72	Yes	
7040	4801-JZAZL	Female	0	Yes	Yes	11	No	
7041	8361-LTMKD	Male	1	Yes	No	4	Yes	
7042	3186-AJIEK	Male	0	No	No	66	Yes	

5 rows × 21 columns

```
data.isna()
#to see the number of  missing values
```

	customerID	gender	SeniorCitizen	Partner	Dependents	tenure	PhoneService	Mult
0	False	False	False	False	False	False	False	

```
data.isna().sum()
```

```
customerID          0
gender              0
SeniorCitizen       0
Partner             0
Dependents          0
tenure              0
PhoneService        0
MultipleLines       0
InternetService     0
OnlineSecurity      0
OnlineBackup        0
DeviceProtection    0
TechSupport         0
StreamingTV         0
StreamingMovies     0
Contract            0
PaperlessBilling    0
PaymentMethod       0
MonthlyCharges      0
TotalCharges       11
Churn               0
dtype: int64
```

```
set(data.duplicated())
```

```
{False}
```

```
# we can pass the result of the df.duplicated into a set to see if there is any instance of T
# No duplicates in the data
set(data.duplicated())
```

```
{False}
```

```
data.shape
```

```
(7043, 21)
```

```
# Checking the class imbalance
data['Churn'].value_counts(normalize=True)
```

```
No     0.73463
Yes    0.26537
Name: Churn, dtype: float64
```

```
df=data
```

```
df.head()
```

	customerID	gender	SeniorCitizen	Partner	Dependents	tenure	PhoneService	Multipl
0	7590-VHVEG	Female	0	Yes	No	1	No	No
1	5575-GNVDE	Male	0	No	No	34	Yes	
2	3668-QPYBK	Male	0	No	No	2	Yes	
3	7795-CFOCW	Male	0	No	No	45	No	No
4	9237-HQITU	Female	0	No	No	2	Yes	

5 rows × 21 columns

```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 7043 entries, 0 to 7042
Data columns (total 21 columns):
 #   Column            Non-Null Count  Dtype
---  ------            --------------  -----
 0   customerID        7043 non-null   object
 1   gender            7043 non-null   object
 2   SeniorCitizen     7043 non-null   int64
 3   Partner           7043 non-null   object
 4   Dependents        7043 non-null   object
 5   tenure            7043 non-null   int64
 6   PhoneService      7043 non-null   object
 7   MultipleLines     7043 non-null   object
 8   InternetService   7043 non-null   object
 9   OnlineSecurity    7043 non-null   object
 10  OnlineBackup      7043 non-null   object
 11  DeviceProtection  7043 non-null   object
 12  TechSupport       7043 non-null   object
 13  StreamingTV       7043 non-null   object
 14  StreamingMovies   7043 non-null   object
 15  Contract          7043 non-null   object
 16  PaperlessBilling  7043 non-null   object
 17  PaymentMethod     7043 non-null   object
 18  MonthlyCharges    7043 non-null   float64
 19  TotalCharges      7032 non-null   float64
 20  Churn             7043 non-null   object
```

```
dtypes: float64(2), int64(2), object(17)
memory usage: 1.1+ MB
```

```
# HERE
```

```
# To split the data into Churn or not churn
```

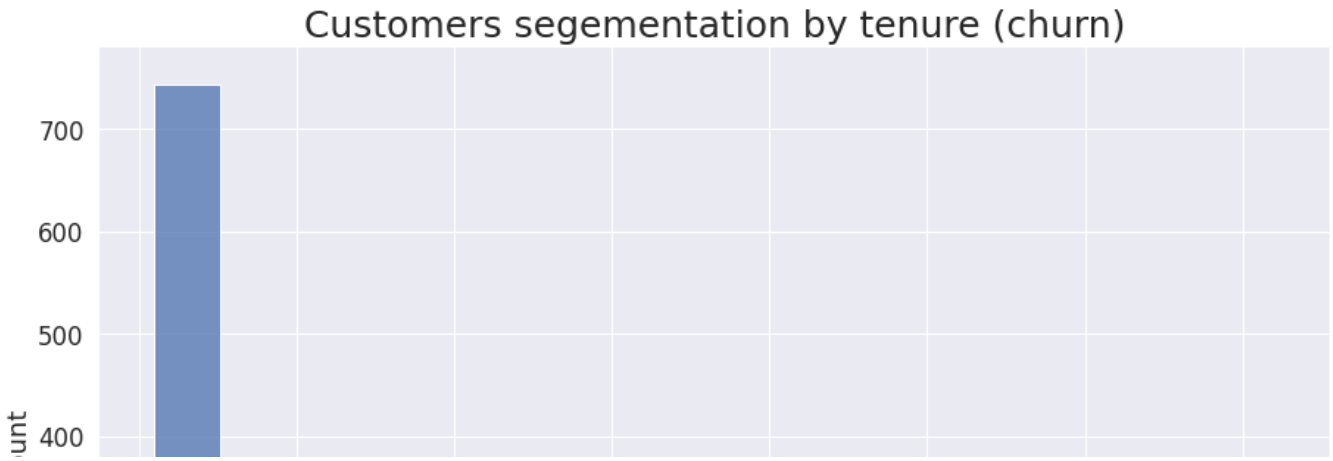
```
#Churn data
ChurnData = df[df["Churn"]=="Yes"]
ChurnData.shape
```

```
(1869, 21)
```

```
# Not Churn data
NotChurnData = df[df["Churn"]=="No"]
NotChurnData.shape
```

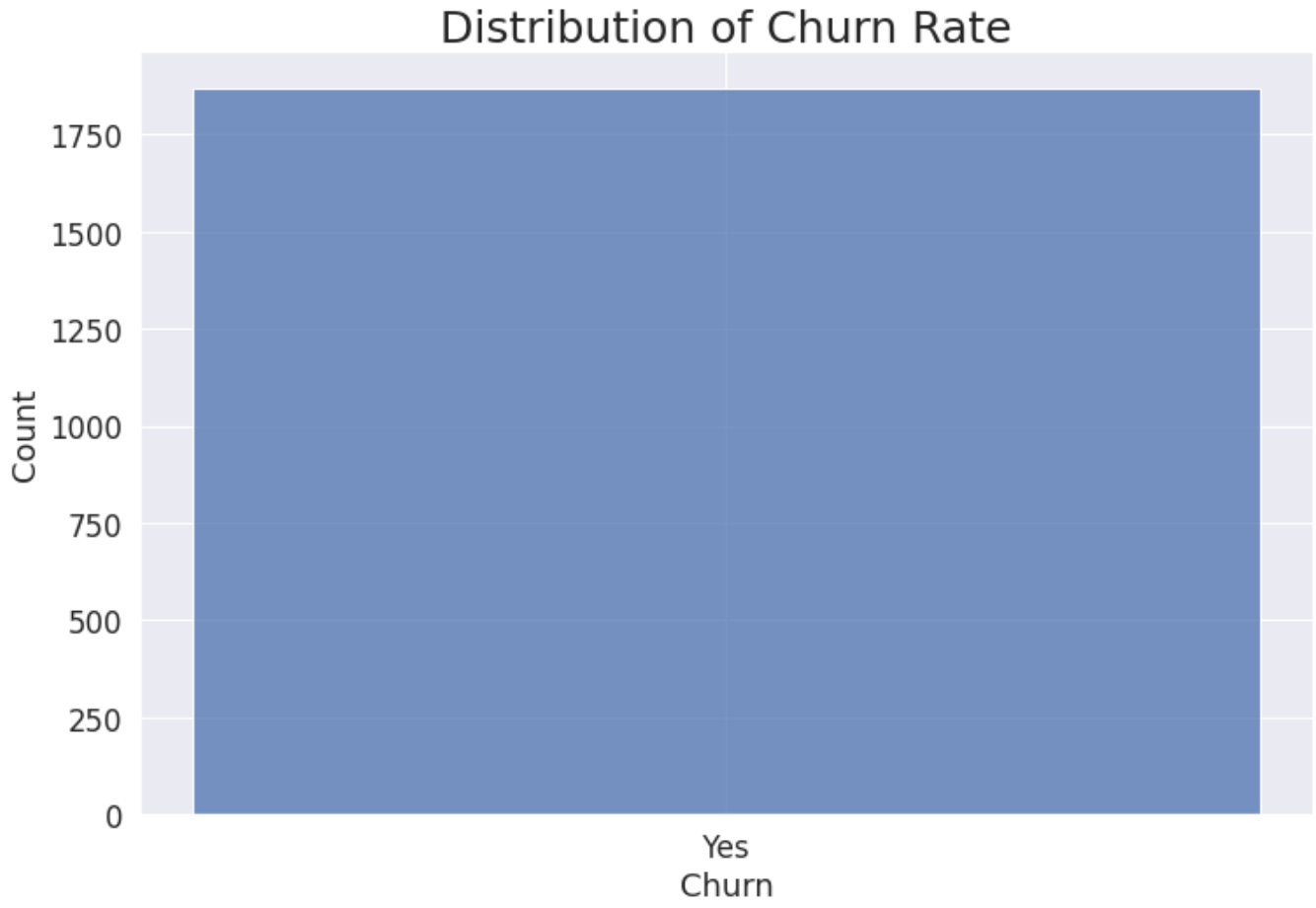
```
(5174, 21)
```

```
plt.figure(figsize=(15,10))
sns.histplot(ChurnData.tenure)
plt.title('Customers segementation by tenure (churn)', fontsize = 25)
plt.show()
```




```
plt.figure(figsize=(15,10))
sns.histplot(NotChurnData.tenure)
plt.title('Customers segementation by tenure (not churn)', fontsize = 25)
plt.show()
```

```
plt.figure(figsize=(12,8))
sns.histplot(ChurnData.Churn)
plt.title('Distribution of Churn Rate', fontsize = 25)
plt.show()
```




```
df.nunique()
```

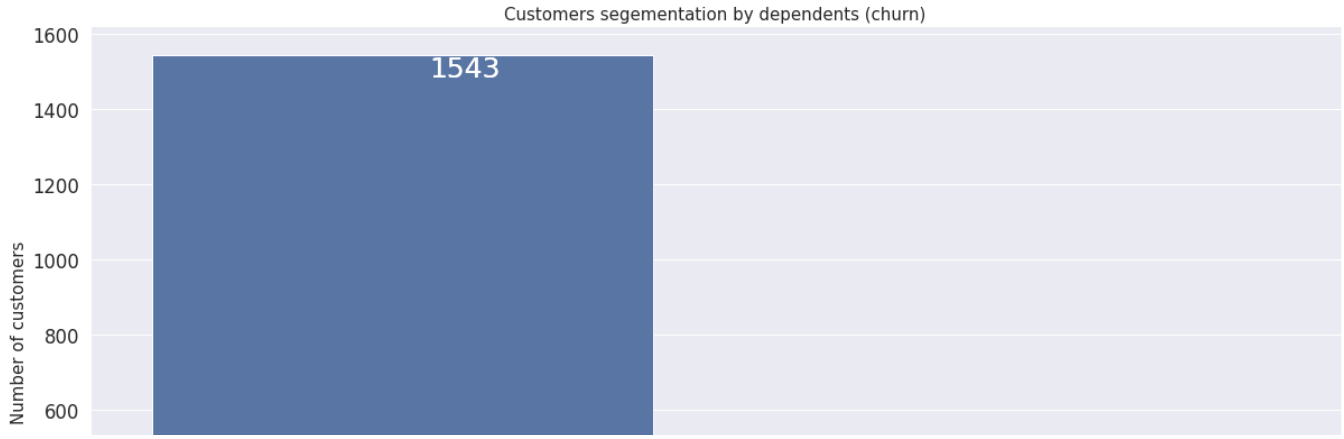
```
customerID          7043
gender                 2
SeniorCitizen          2
Partner                2
Dependents             2
tenure                73
PhoneService           2
MultipleLines          3
InternetService        3
OnlineSecurity         3
OnlineBackup           3
DeviceProtection       3
TechSupport            3
StreamingTV            3
StreamingMovies        3
```

```
Contract               3
PaperlessBilling       2
PaymentMethod          4
MonthlyCharges      1585
TotalCharges        6530
Churn                  2
dtype: int64
```

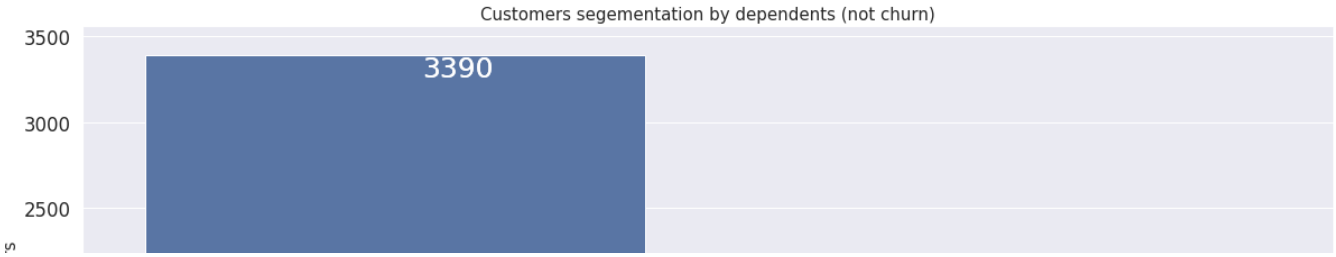
```
df['Dependents'].value_counts()
```

```
No     4933
Yes    2110
Name: Dependents, dtype: int64
```

```
plt.figure(figsize=(20,10))
ax=sns.countplot(x='Dependents', data=ChurnData)
ax.set_title('Customers segementation by dependents (churn)' , fontsize = 15)
sns.set(font_scale=1.5)
plt.xlabel('Dependents', fontsize=15)
plt.ylabel('Number of customers', fontsize=15)
plt.xticks(rotation='vertical')
for p in ax.patches:
    for p in ax.patches:
        ax.annotate(format(p.get_height(), '.0f'),
                    (p.get_x()+0.5, p.get_height()), ha='center', va='top', color='white', si
```



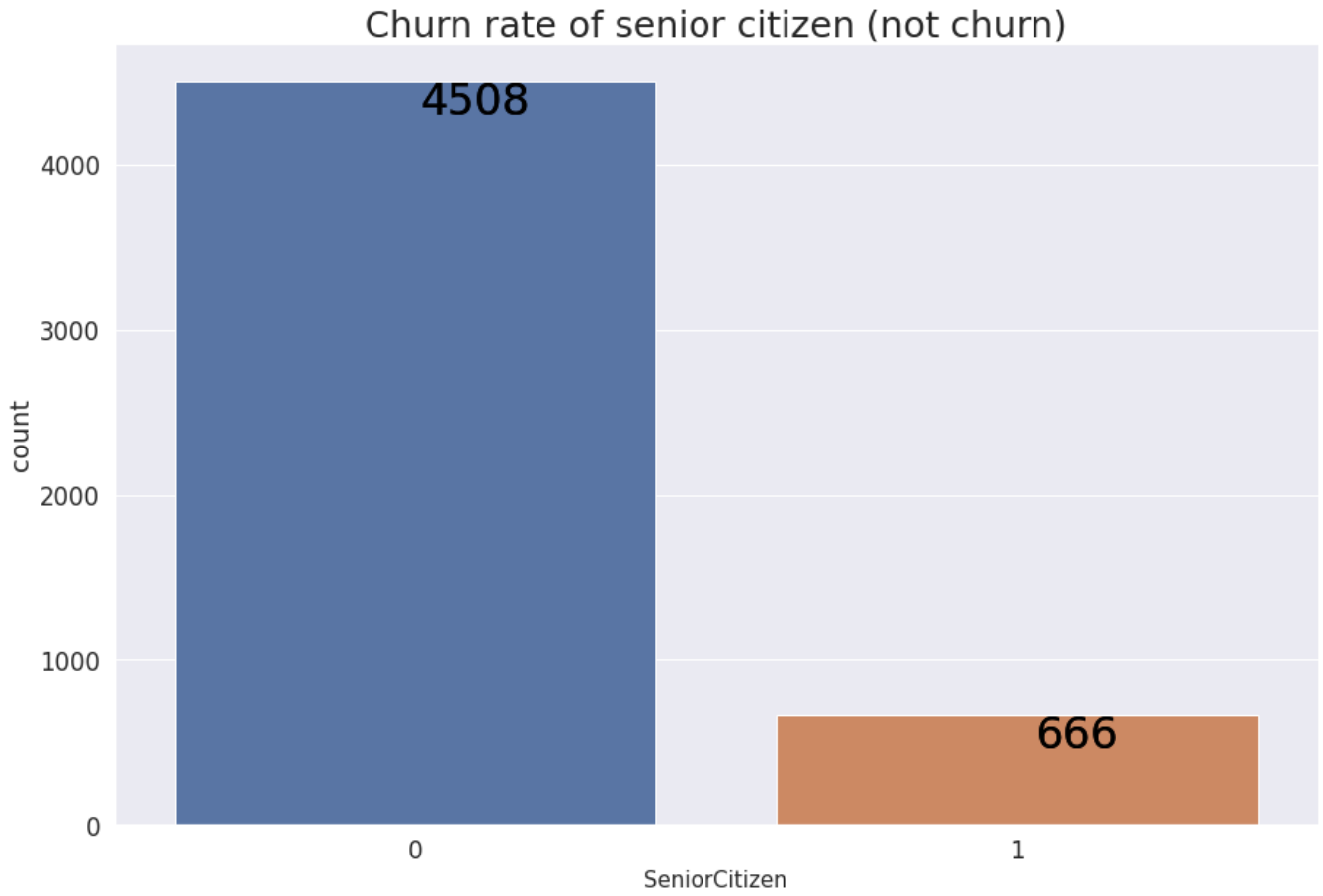

```
plt.figure(figsize=(20,10))
ax=sns.countplot(x='Dependents', data=NotChurnData)
ax.set_title('Customers segementation by dependents (not churn)' , fontsize = 15)
sns.set(font_scale=1.5)
plt.xlabel('Dependents', fontsize=15)
plt.ylabel('Number of customers', fontsize=15)
plt.xticks(rotation='vertical')
for p in ax.patches:
    for p in ax.patches:
        ax.annotate(format(p.get_height(), '.0f'),
                    (p.get_x()+0.5, p.get_height()), ha='center', va='top', color='white', si
```




```
plt.figure(figsize=(20,10))
ax=sns.countplot(x='SeniorCitizen', data=ChurnData)
ax.set_title('Churn rate of senior citizen (churn)' , fontsize = 25)
plt.xlabel('Senior citizen', fontsize=15)
plt.xticks(rotation='horizontal')
for p in ax.patches:
    for p in ax.patches:
        ax.annotate(format(p.get_height(), '.0f'),
                    (p.get_x()+0.5, p.get_height()), ha='center', va='top', color='black', si
```

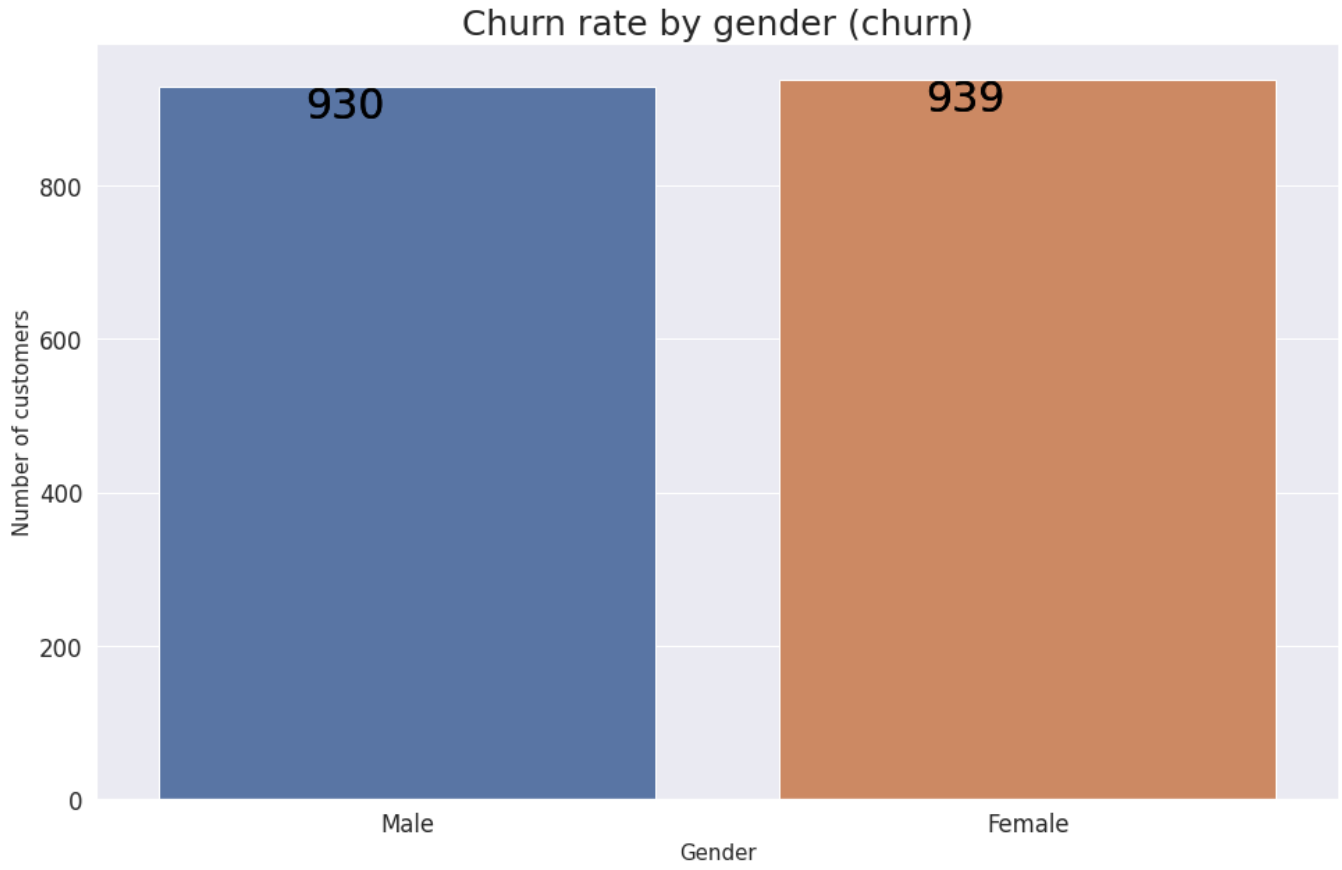
Churn rate of senior citizen (churn)

```
plt.figure(figsize=(15,10))
ax=sns.countplot(x='SeniorCitizen', data=NotChurnData)
ax.set_title('Churn rate of senior citizen (not churn)' , fontsize = 25)
plt.xlabel('SeniorCitizen', fontsize=15)
plt.xticks(rotation='horizontal')
for p in ax.patches:
    for p in ax.patches:
        ax.annotate(format(p.get_height(), '.0f'),
                    (p.get_x()+0.5, p.get_height()), ha='center', va='top', color='black', si
```



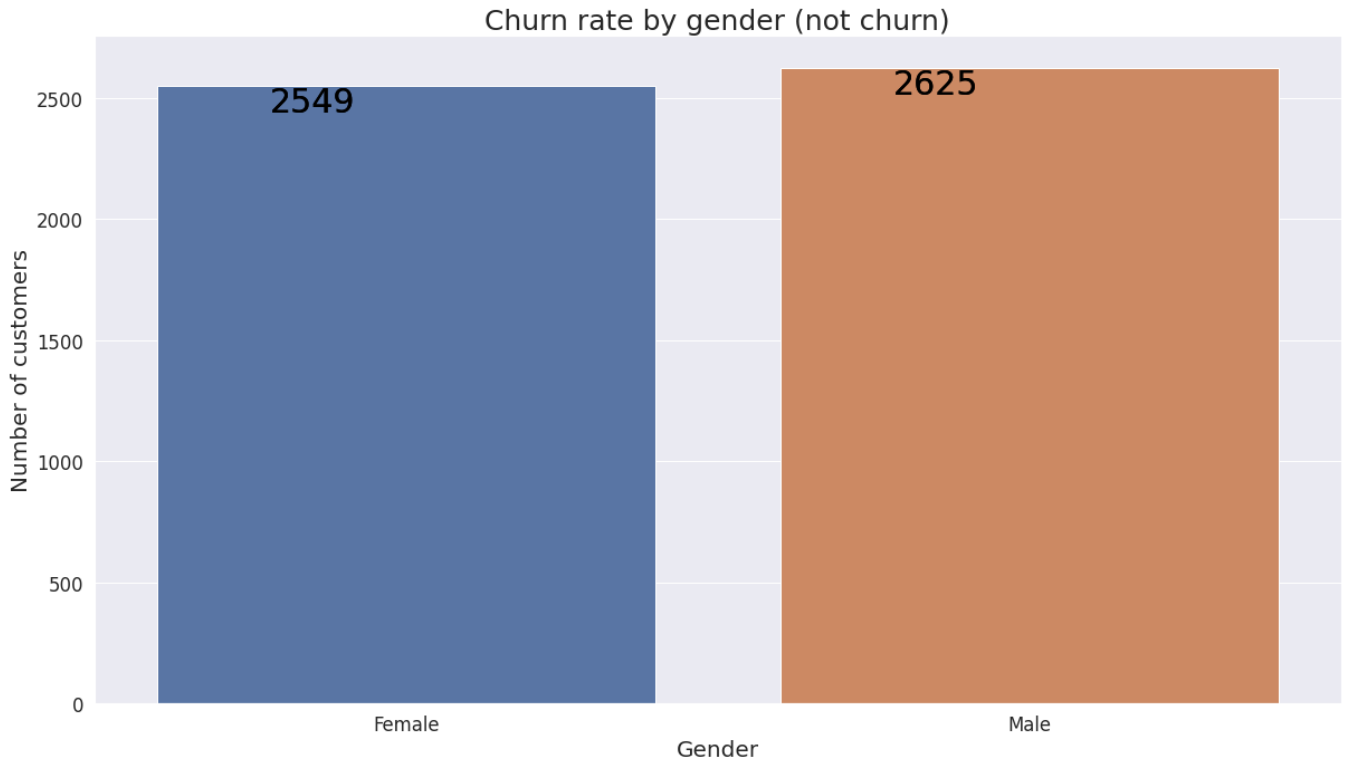

```
plt.figure(figsize=(16,10))
ax=sns.countplot(x='gender', data=ChurnData)
ax.set_title('Churn rate by gender (churn)' , fontsize = 25)
```

```
plt.xlabel('Gender', fontsize=15)
plt.ylabel('Number of customers', fontsize=15)
plt.xticks(rotation='horizontal')
for p in ax.patches:
    for p in ax.patches:
        ax.annotate(format(p.get_height(), '.0f'),
                    (p.get_x()+0.3, p.get_height()), ha='center', va='top', color='black', si
```




```
plt.figure(figsize=(20,11))
ax=sns.countplot(x='gender', data=NotChurnData)
ax.set_title('Churn rate by gender (not churn)' , fontsize = 25)
plt.xlabel('Gender', fontsize=20)
```

```
plt.ylabel('Number of customers', fontsize=20)
plt.xticks(rotation='horizontal')
for p in ax.patches:
    for p in ax.patches:
        ax.annotate(format(p.get_height(), '.0f'),
                    (p.get_x()+0.25, p.get_height()), ha='center', va='top', color='black', s
```



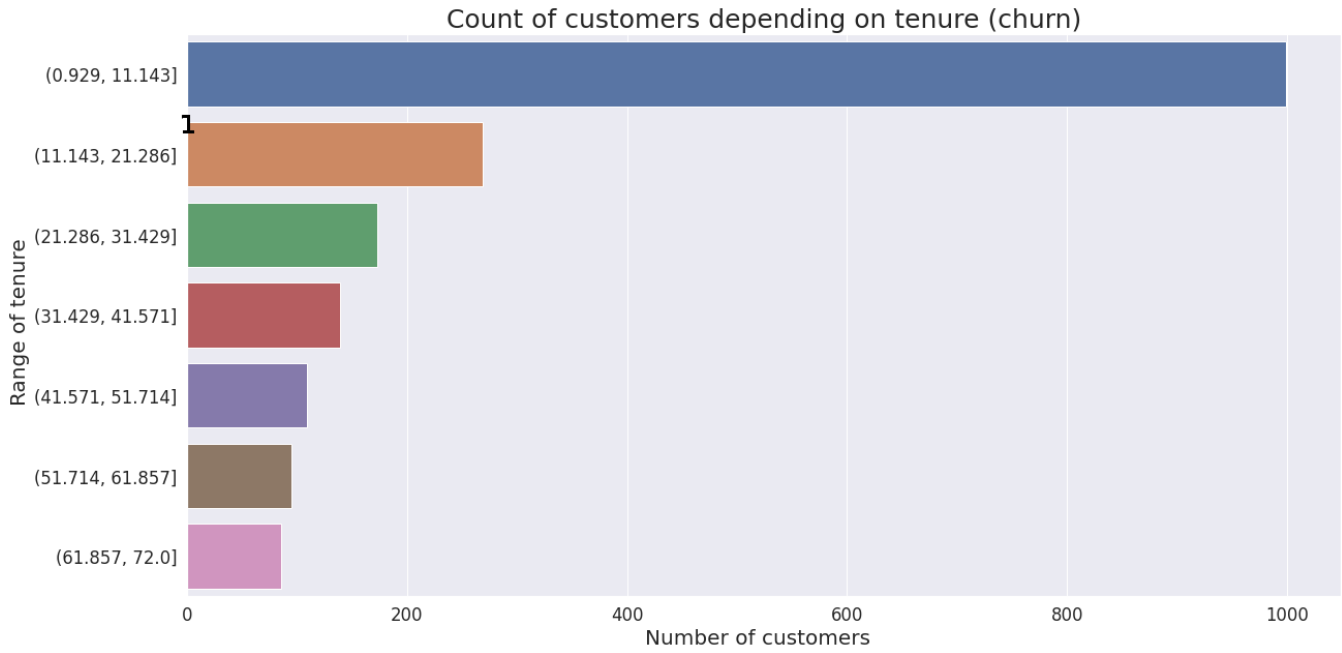

```
df.nunique()
```

```
customerID          7043
gender                 2
SeniorCitizen          2
Partner                2
```

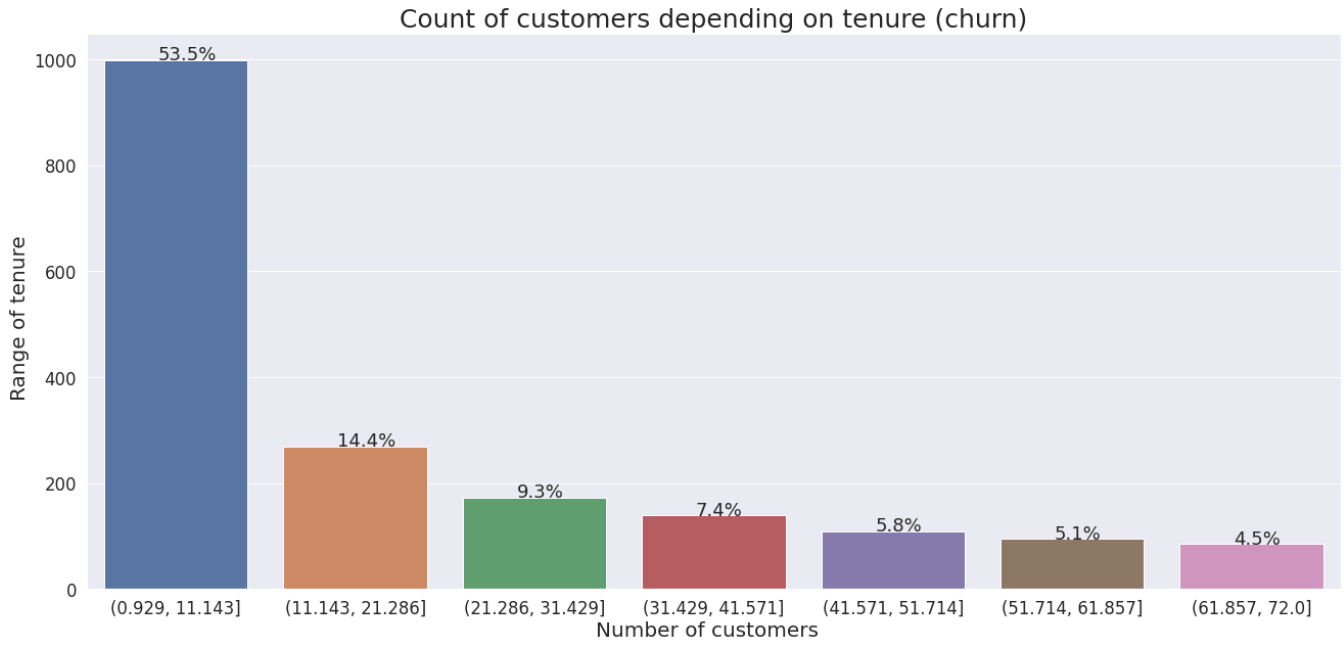
```
Dependents             2
tenure                73
PhoneService           2
MultipleLines          3
InternetService        3
OnlineSecurity         3
OnlineBackup           3
DeviceProtection       3
TechSupport            3
StreamingTV            3
StreamingMovies        3
Contract               3
PaperlessBilling       2
PaymentMethod          4
MonthlyCharges      1585
TotalCharges        6530
Churn                  2
dtype: int64
```

```
binsA = pd.cut(ChurnData['tenure'], 7)
bins1 = pd.cut(NotChurnData['tenure'], 7)
dfChurn = ChurnData['tenure']
```

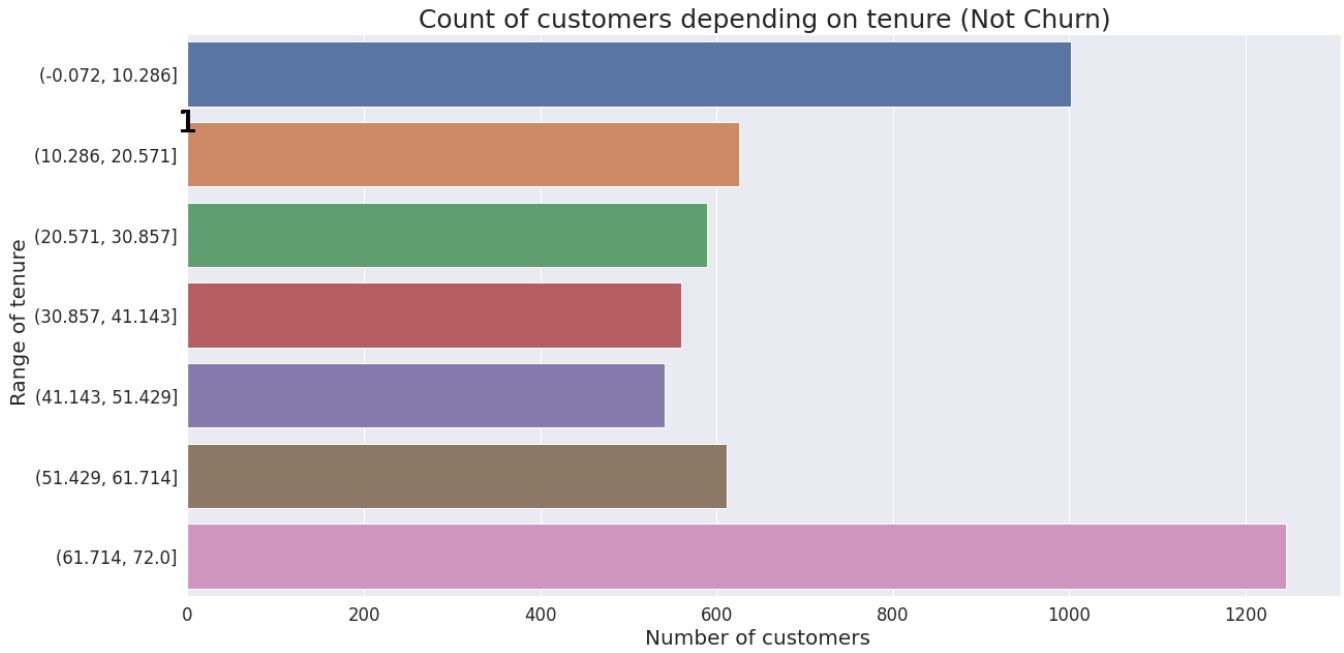
```
plt.figure(figsize=(20,10))
ax=sns.countplot(y=binsA)
sns.set(font_scale=1.5)
ax.set_title('Count of customers depending on tenure (churn)' , fontsize = 25)
plt.xlabel('Number of customers  ', fontsize=20)
plt.ylabel('Range of tenure  ', fontsize=20)
plt.xticks(rotation='horizontal')
for p in ax.patches:
    for p in ax.patches:
        ax.annotate(format(p.get_height(), '.0f'),
                    (p.get_x()+0.3, p.get_height()), ha='center', va='bottom', color='black',
```



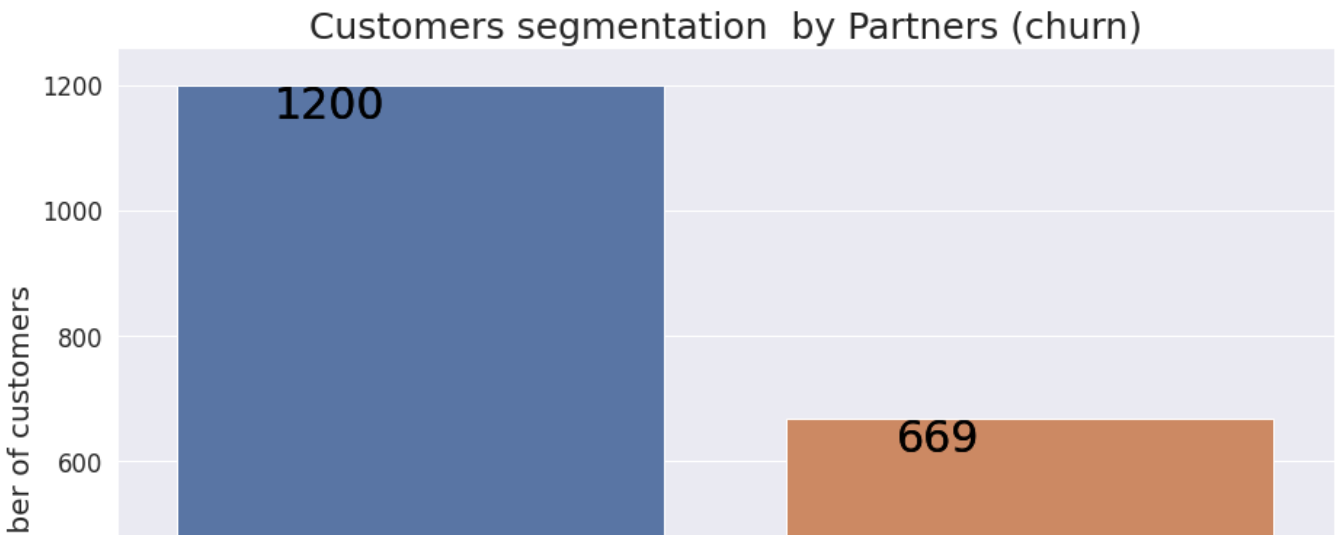

```
plt.figure(figsize=(22,10))
ax=sns.countplot(x=binsA)
sns.set(font_scale=1.5)
ax.set_title('Count of customers depending on tenure (churn)' , fontsize = 25)
plt.xlabel('Number of customers  ', fontsize=20)
plt.ylabel('Range of tenure  ', fontsize=20)
plt.xticks(rotation='horizontal')

total = float(len(ChurnData))
for p in ax.patches:
    percentage = '{:.1f}%'.format(100 * p.get_height()/total)
    x = p.get_x() + p.get_width() / 2 - 0.1
    y = p.get_y() + p.get_height()
    ax.annotate(percentage, (x, y), size=18)
```



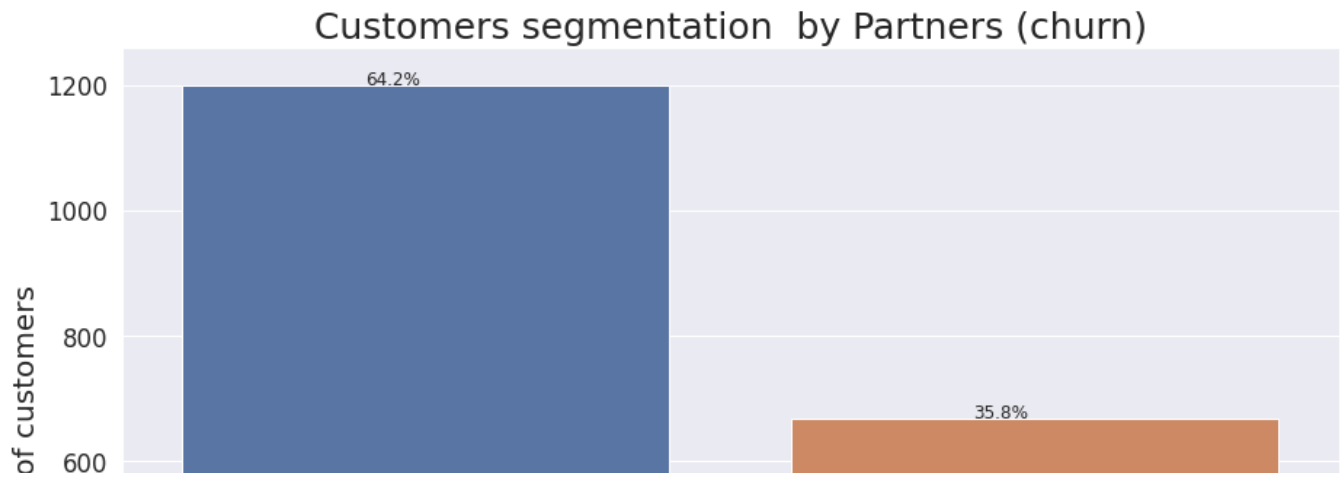

```
plt.figure(figsize=(20,10))
ax=sns.countplot(y=bins1)
sns.set(font_scale=1.5)
ax.set_title('Count of customers depending on tenure (Not Churn)' , fontsize = 25)
plt.xlabel('Number of customers  ', fontsize=20)
plt.ylabel('Range of tenure  ', fontsize=20)
plt.xticks(rotation='horizontal')
for p in ax.patches:
    for p in ax.patches:
        ax.annotate(format(p.get_height(), '.0f'),
                    (p.get_x()+0.3, p.get_height()), ha='center', va='bottom', color='black',
```



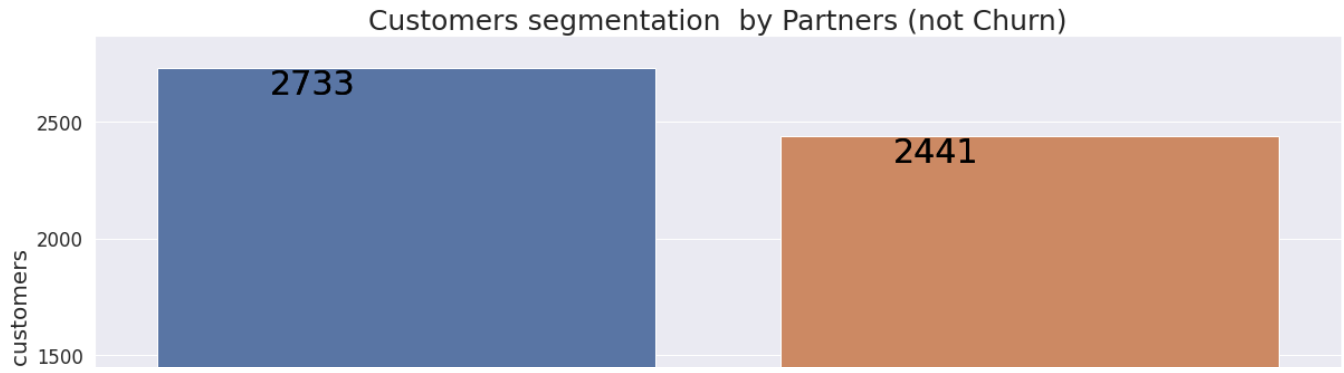

```
plt.figure(figsize=(15,10))
ax=sns.countplot(x='Partner', data=ChurnData)
ax.set_title('Customers segmentation  by Partners (churn)' , fontsize = 25)
plt.xlabel('Partner', fontsize=20)
plt.ylabel('Number of customers', fontsize=20)
plt.xticks(rotation='horizontal')
for p in ax.patches:
    for p in ax.patches:
        ax.annotate(format(p.get_height(), '.0f'),
                    (p.get_x()+0.25, p.get_height()), ha='center', va='top', color='black', s
```



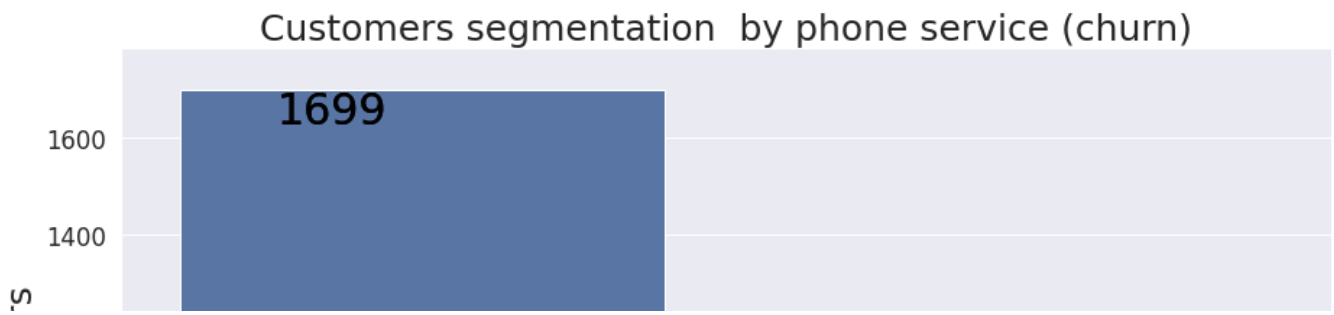

```
plt.figure(figsize=(15,10))
ax=sns.countplot(x='Partner', data=ChurnData)
ax.set_title('Customers segmentation  by Partners (churn)' , fontsize = 25)
plt.xlabel('Partner', fontsize=20)
plt.ylabel('Number of customers', fontsize=20)
plt.xticks(rotation='horizontal')


total = float(len(ChurnData))
for p in ax.patches:
    percentage = '{:.1f}%'.format(100 * p.get_height()/total)
    x = p.get_x() + p.get_width() / 2 - 0.1
    y = p.get_y() + p.get_height()
    ax.annotate(percentage, (x, y), size=12)
```



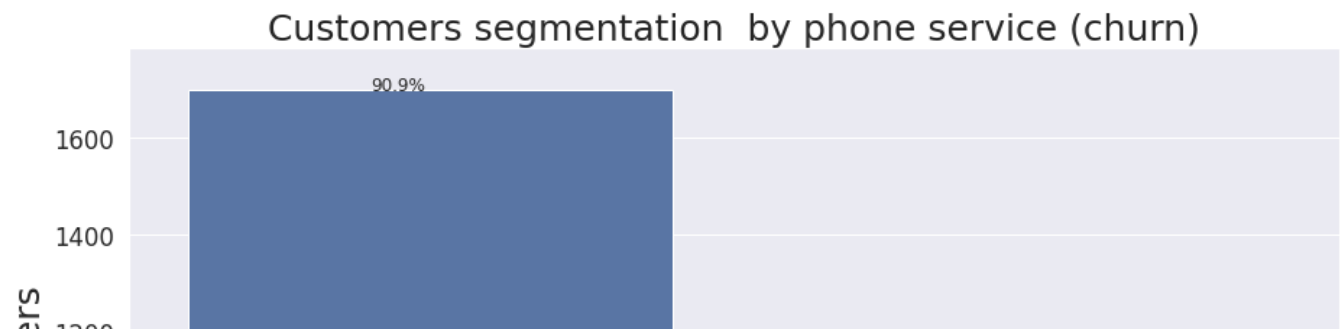

```
plt.figure(figsize=(20,11))
ax=sns.countplot(x='Partner', data=NotChurnData)
ax.set_title('Customers segmentation  by Partners (not Churn)' , fontsize = 25)
plt.xlabel('Partner', fontsize=20)
plt.ylabel('Number of customers', fontsize=20)
plt.xticks(rotation='horizontal')
for p in ax.patches:
    for p in ax.patches:
        ax.annotate(format(p.get_height(), '.0f'),
                    (p.get_x()+0.25, p.get_height()), ha='center', va='top', color='black', s
```



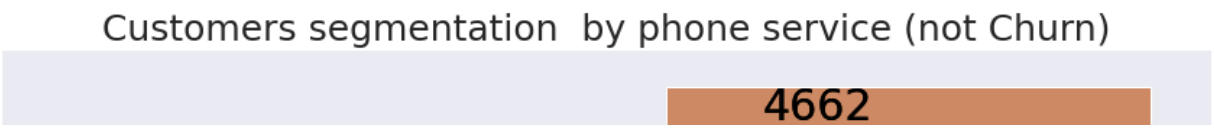

```
plt.figure(figsize=(15,11))
ax=sns.countplot(x='PhoneService', data=ChurnData)
ax.set_title('Customers segmentation  by phone service (churn)' , fontsize = 25)
plt.xlabel('PhoneService', fontsize=25)
plt.ylabel('Number of customers', fontsize=25)
plt.xticks(rotation='horizontal')
for p in ax.patches:
    for p in ax.patches:
        ax.annotate(format(p.get_height(), '.0f'),
                    (p.get_x()+0.25, p.get_height()), ha='center', va='top', color='black', s
```



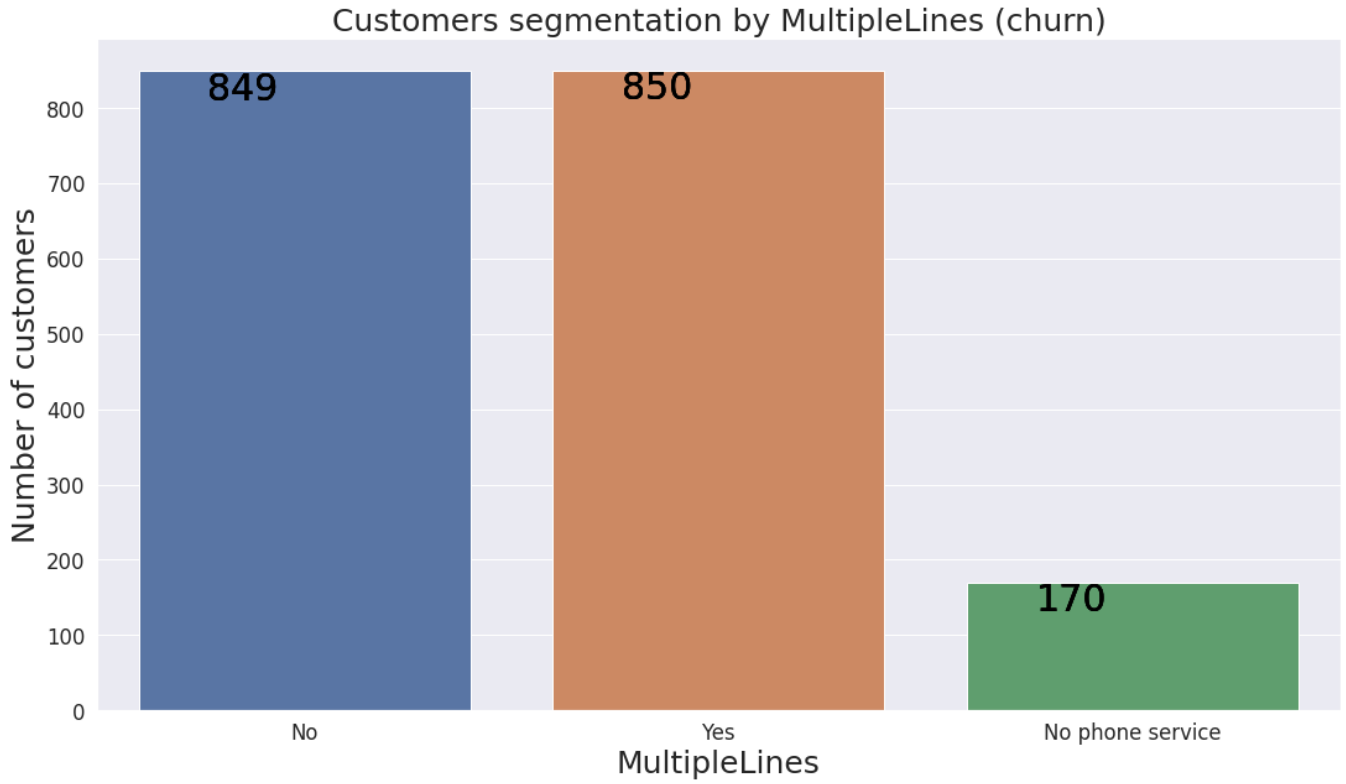

```
plt.figure(figsize=(15,11))
ax=sns.countplot(x='PhoneService', data=ChurnData)
ax.set_title('Customers segmentation  by phone service (churn)' , fontsize = 25)
plt.xlabel('PhoneService', fontsize=25)
plt.ylabel('Number of customers', fontsize=25)
plt.xticks(rotation='horizontal')

total = float(len(ChurnData))
for p in ax.patches:
    percentage = '{:.1f}%'.format(100 * p.get_height()/total)
    x = p.get_x() + p.get_width() / 2 - 0.1
    y = p.get_y() + p.get_height()
    ax.annotate(percentage, (x, y), size=12)
```



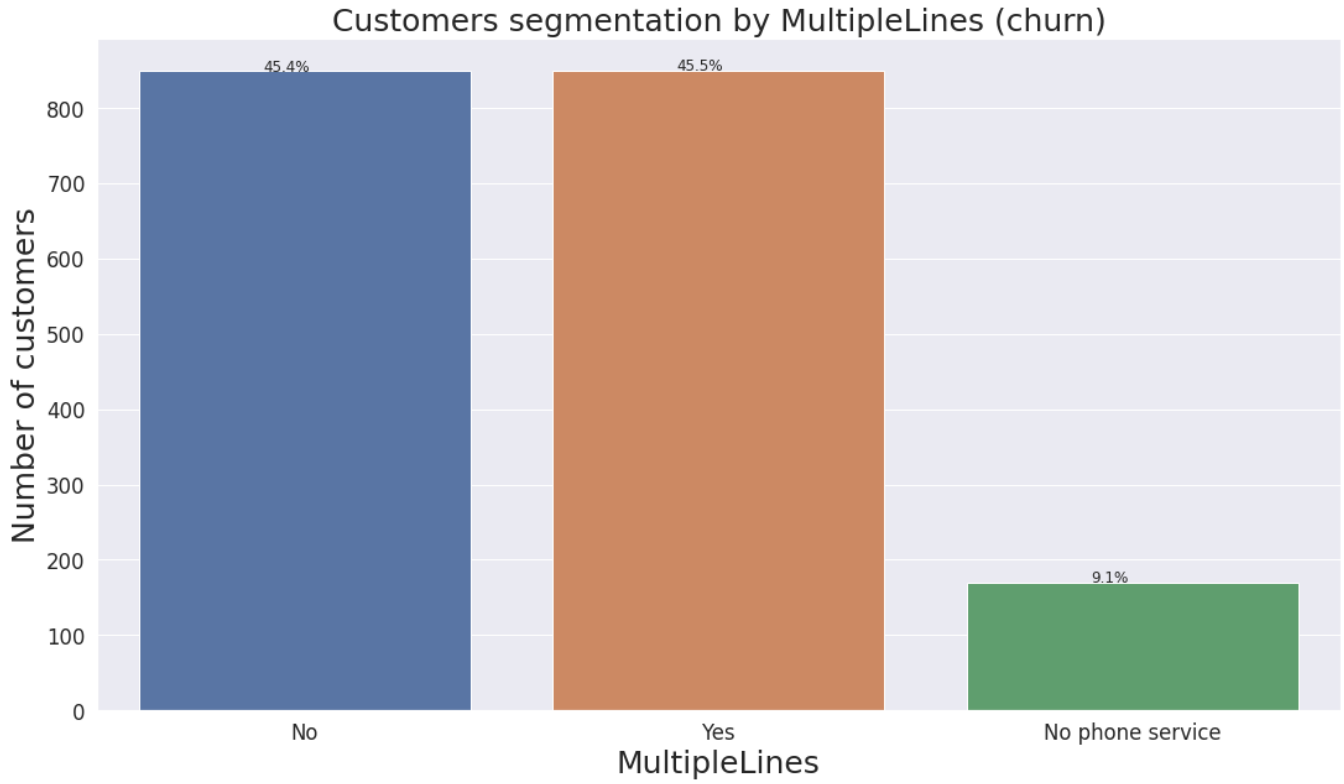

```
plt.figure(figsize=(15,10))
ax=sns.countplot(x='PhoneService', data=NotChurnData)
ax.set_title('Customers segmentation  by phone service (not Churn)' , fontsize = 25)
plt.xlabel('PhoneService', fontsize=25)
plt.ylabel('Number of customers', fontsize=25)
plt.xticks(rotation='horizontal')
for p in ax.patches:
    for p in ax.patches:
        ax.annotate(format(p.get_height(), '.0f'),
                    (p.get_x()+0.25, p.get_height()), ha='center', va='top', color='black', s
```



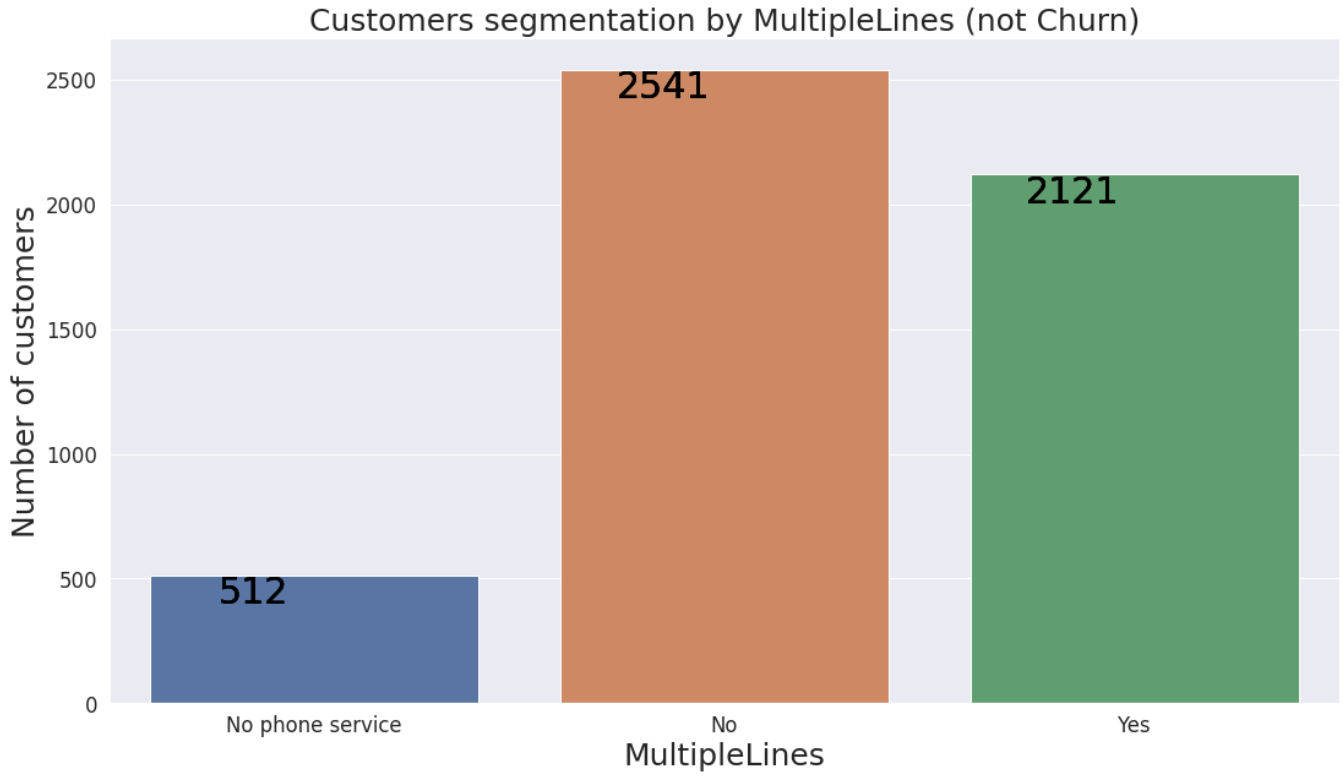

```
plt.figure(figsize=(18,10))
ax=sns.countplot(x='MultipleLines', data=ChurnData)
sns.set(font_scale=1.5)
ax.set_title('Customers segmentation by MultipleLines (churn)' , fontsize = 25)
plt.xlabel('MultipleLines', fontsize=25)
plt.ylabel('Number of customers', fontsize=25)
plt.xticks(rotation='horizontal')
for p in ax.patches:
    for p in ax.patches:
        ax.annotate(format(p.get_height(), '.0f'),
                    (p.get_x()+0.25, p.get_height()), ha='center', va='top', color='black', s
```



```
plt.figure(figsize=(18,10))
ax=sns.countplot(x='MultipleLines', data=ChurnData)
sns.set(font_scale=1.5)
ax.set_title('Customers segmentation by MultipleLines (churn)' , fontsize = 25)
plt.xlabel('MultipleLines', fontsize=25)
plt.ylabel('Number of customers', fontsize=25)
plt.xticks(rotation='horizontal')


total = float(len(ChurnData))
for p in ax.patches:
    percentage = '{:.1f}%'.format(100 * p.get_height()/total)
    x = p.get_x() + p.get_width() / 2 - 0.1
    y = p.get_y() + p.get_height()
    ax.annotate(percentage, (x, y), size=12)
```

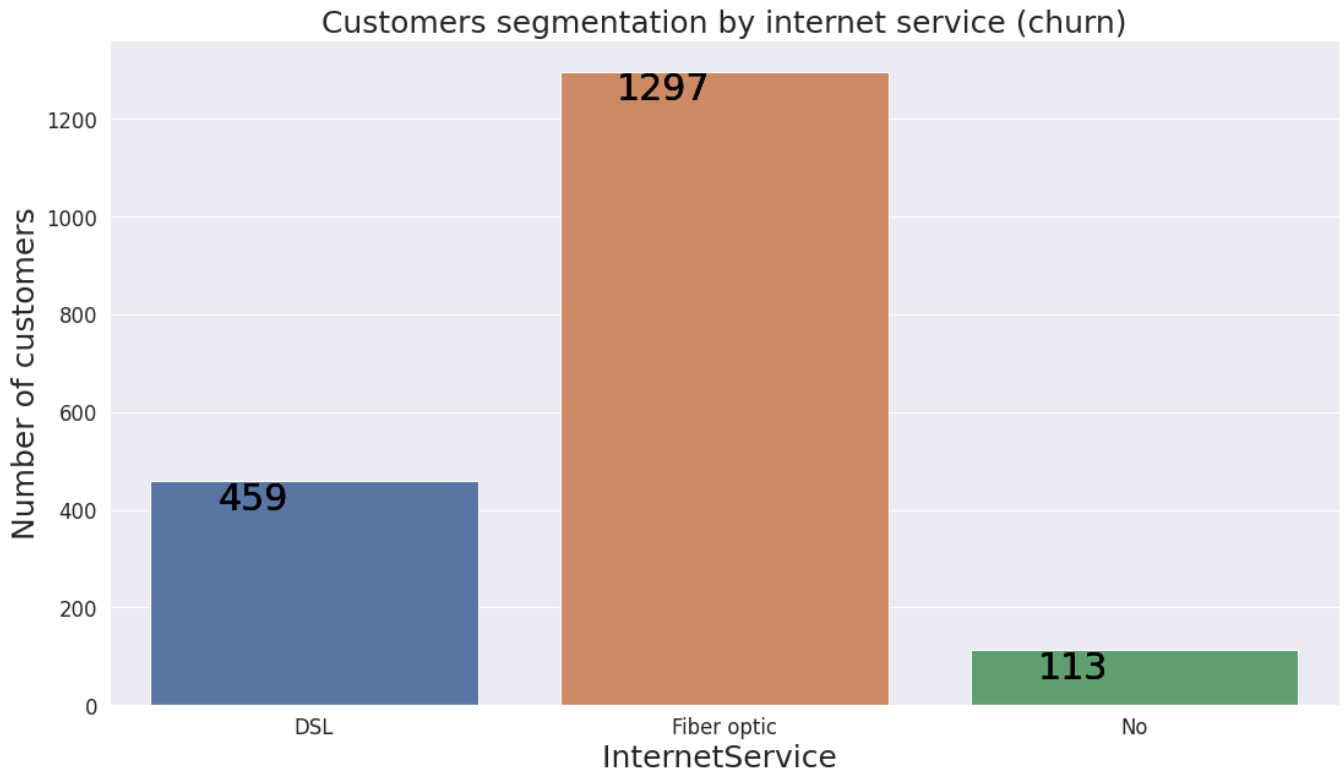


```
plt.figure(figsize=(18,10))
ax=sns.countplot(x='MultipleLines', data=NotChurnData)
sns.set(font_scale=1.5)
ax.set_title('Customers segmentation by MultipleLines (not Churn)' , fontsize = 25)
plt.xlabel('MultipleLines', fontsize=25)
plt.ylabel('Number of customers', fontsize=25)
plt.xticks(rotation='horizontal')
for p in ax.patches:
    for p in ax.patches:
        ax.annotate(format(p.get_height(), '.0f'),
                    (p.get_x()+0.25, p.get_height()), ha='center', va='top', color='black', s
```



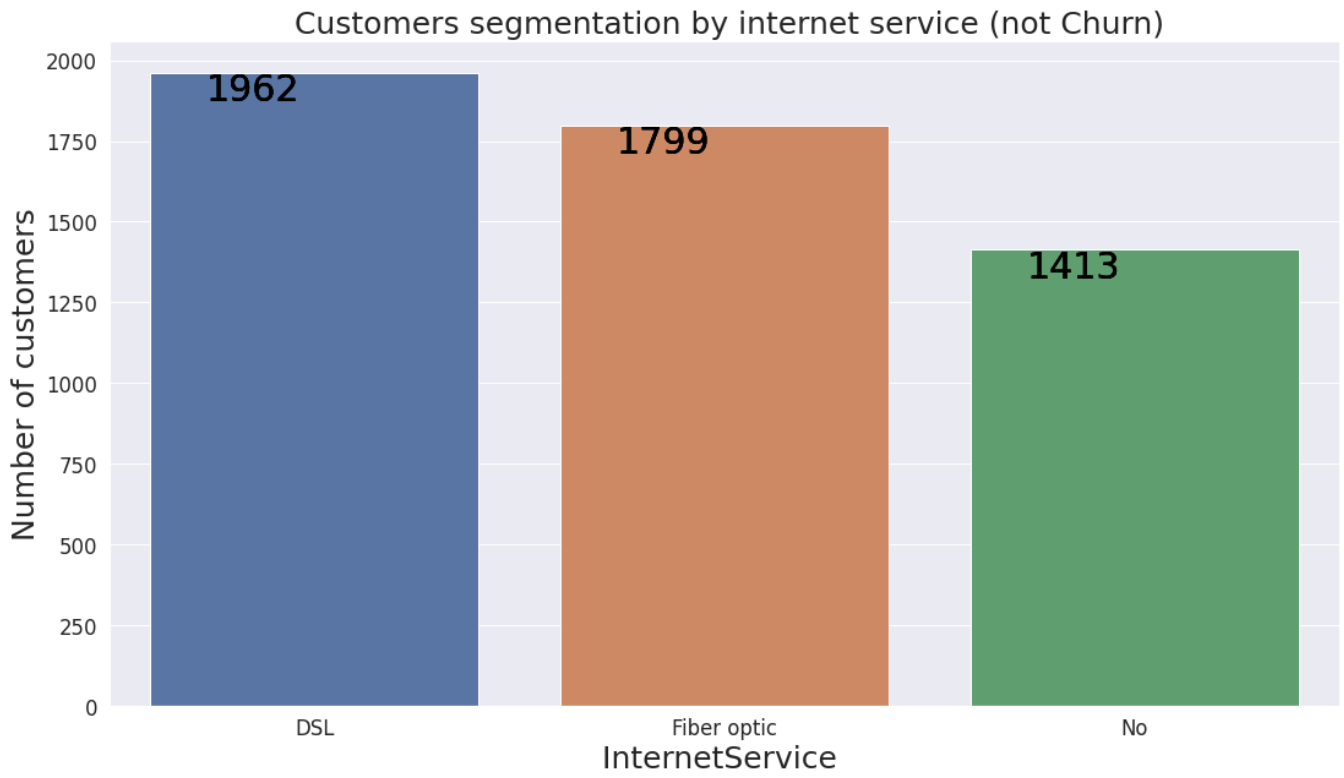

```
plt.figure(figsize=(18,10))
ax=sns.countplot(x='InternetService', data=ChurnData)
sns.set(font_scale=1.5)
ax.set_title('Customers segmentation by internet service (churn)' , fontsize = 25)
```

```
plt.xlabel('InternetService ', fontsize=25)
plt.ylabel('Number of customers', fontsize=25)
plt.xticks(rotation='horizontal')
for p in ax.patches:
    for p in ax.patches:
        ax.annotate(format(p.get_height(), '.0f'),
                    (p.get_x()+0.25, p.get_height()), ha='center', va='top', color='black', s
```

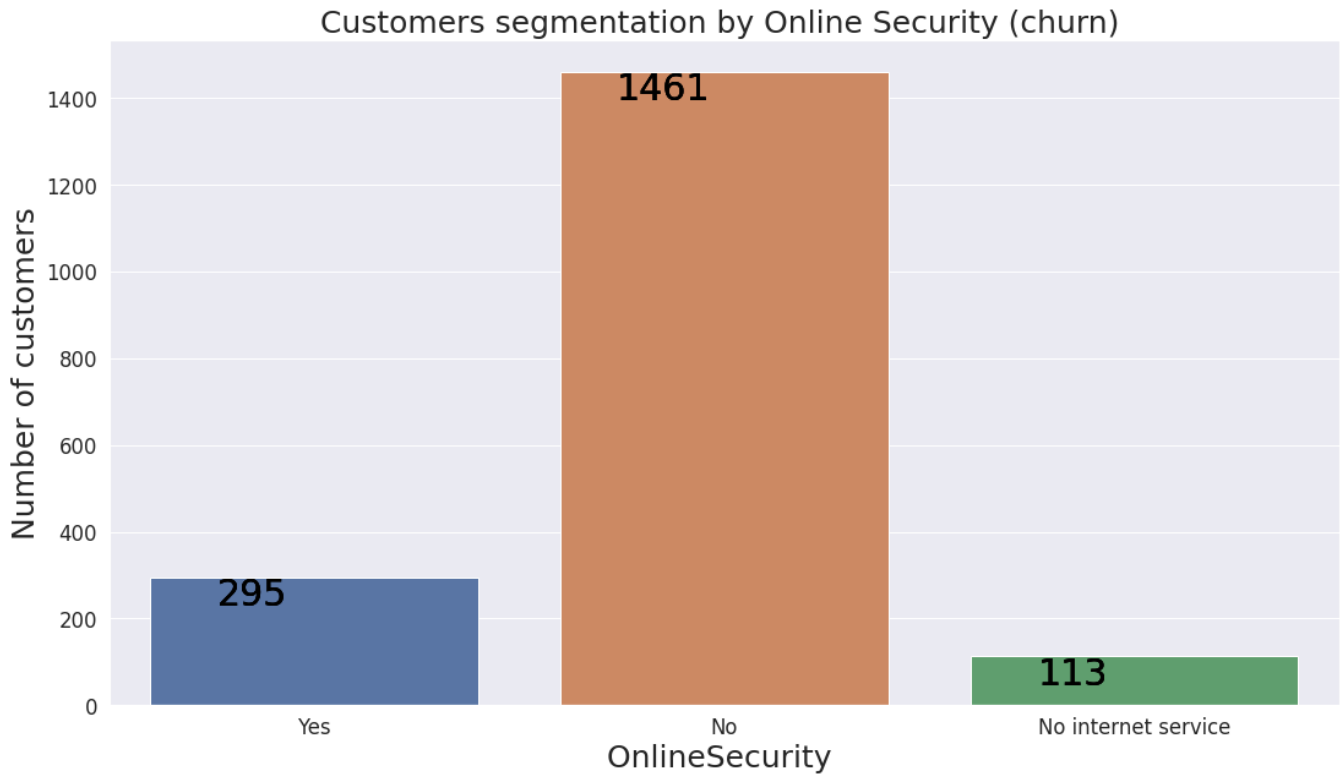



```
plt.figure(figsize=(18,10))
ax=sns.countplot(x='InternetService', data=NotChurnData)
sns.set(font_scale=1.5)
ax.set_title(' Customers segmentation by internet service (not Churn)' , fontsize = 25)
plt.xlabel('InternetService ', fontsize=25)
plt.ylabel('Number of customers', fontsize=25)
plt.xticks(rotation='horizontal')
for p in ax.patches:
```

```
    for p in ax.patches:
        ax.annotate(format(p.get_height(), '.0f'),
                    (p.get_x()+0.25, p.get_height()), ha='center', va='top', color='black', s
```




```
plt.figure(figsize=(18,10))
ax=sns.countplot(x='OnlineSecurity', data=ChurnData)
sns.set(font_scale=1.5)
ax.set_title('Customers segmentation by Online Security (churn) ' , fontsize = 25)
plt.xlabel('OnlineSecurity ', fontsize=25)
plt.ylabel('Number of customers', fontsize=25)
plt.xticks(rotation='horizontal')
for p in ax.patches:
    for p in ax.patches:
        ax.annotate(format(p.get_height(), '.0f'),
                    (p.get_x()+0.25, p.get_height()), ha='center', va='top', color='black', s
```

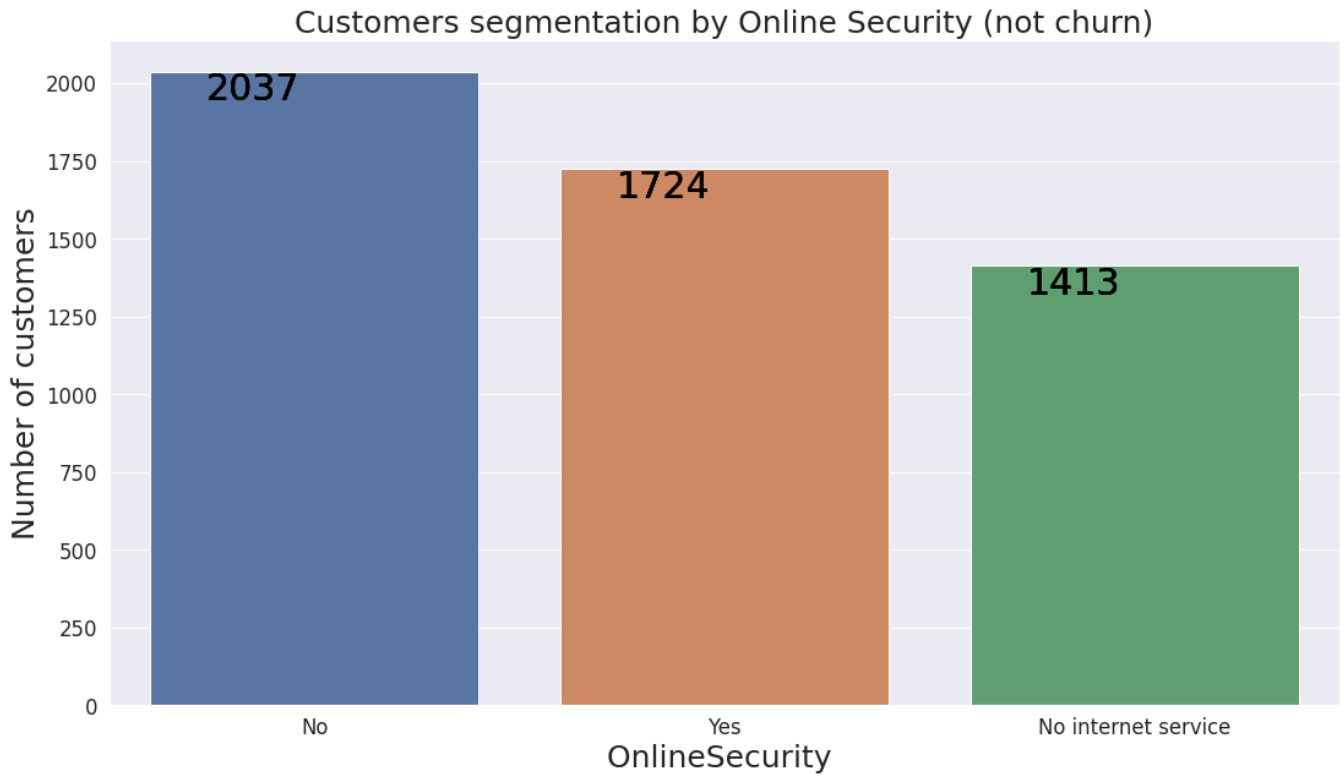



```
plt.figure(figsize=(18,10))
ax=sns.countplot(x='OnlineSecurity', data=ChurnData)
sns.set(font_scale=1.5)
ax.set_title('Customers segmentation by Online Security (churn) ' , fontsize = 25)
plt.xlabel('OnlineSecurity ', fontsize=25)
plt.ylabel('Number of customers', fontsize=25)
plt.xticks(rotation='horizontal')
```

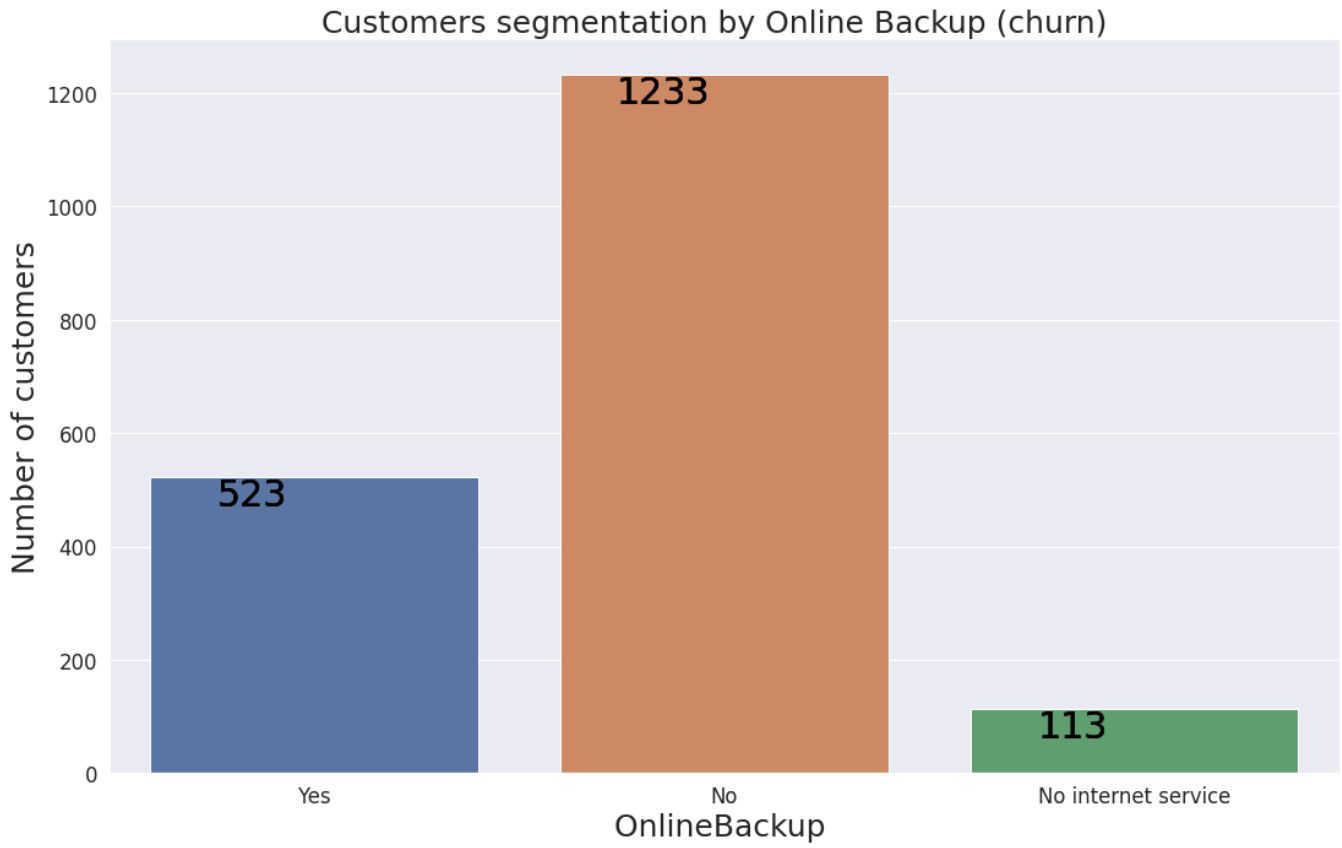
```
total = float(len(ChurnData))
for p in ax.patches:
    percentage = '{:.1f}%'.format(100 * p.get_height()/total)
    x = p.get_x() + p.get_width() / 2 - 0.1
    y = p.get_y() + p.get_height()
```

```
    ax.annotate(percentage, (x, y), size=12)
```

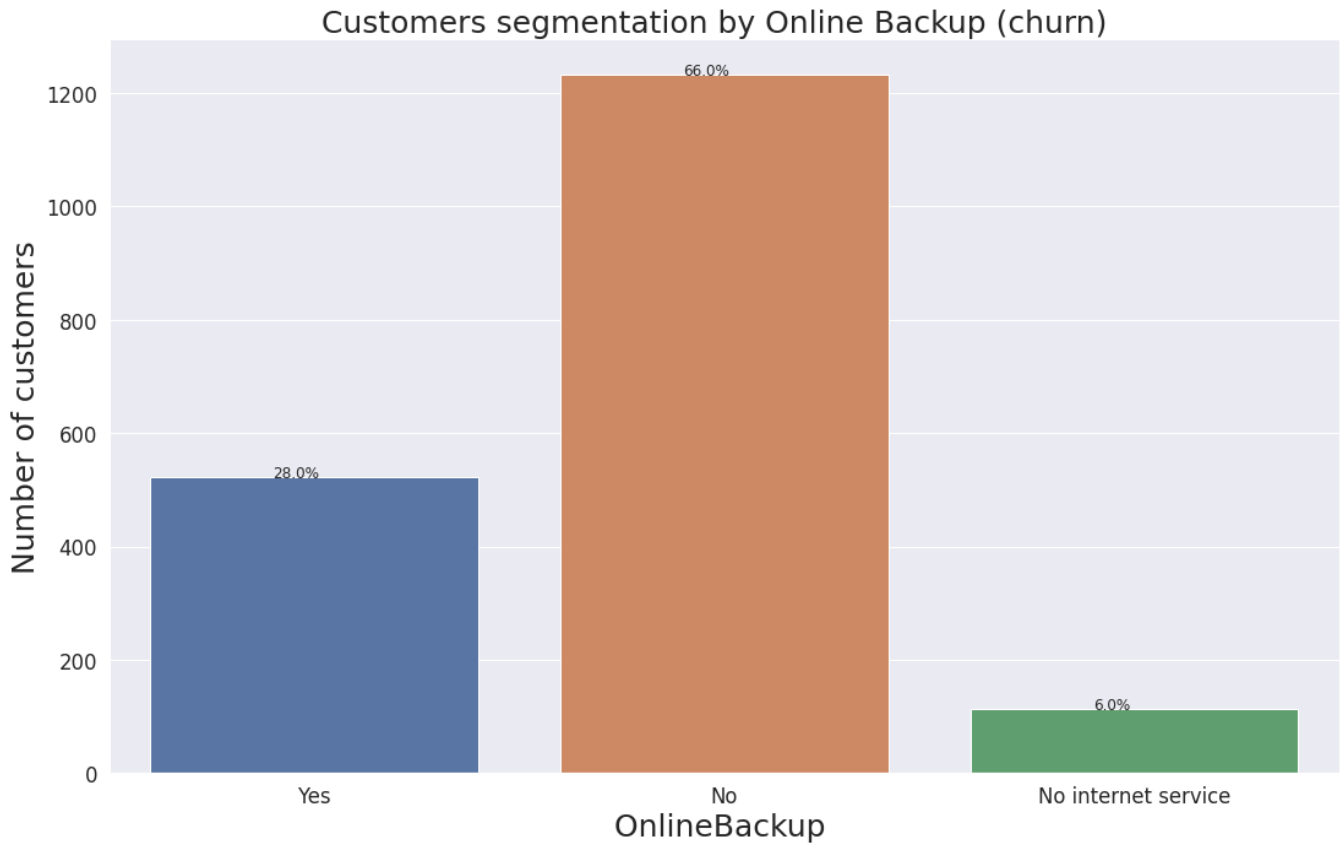

```
plt.figure(figsize=(18,10))
ax=sns.countplot(x='OnlineSecurity', data=NotChurnData)
sns.set(font_scale=1.5)
ax.set_title('Customers segmentation by Online Security (not churn)' , fontsize = 25)
plt.xlabel('OnlineSecurity ', fontsize=25)
plt.ylabel('Number of customers', fontsize=25)
plt.xticks(rotation='horizontal')
for p in ax.patches:
    for p in ax.patches:
        ax.annotate(format(p.get_height(), '.0f'),
                    (p.get_x()+0.25, p.get_height()), ha='center', va='top', color='black', s
```



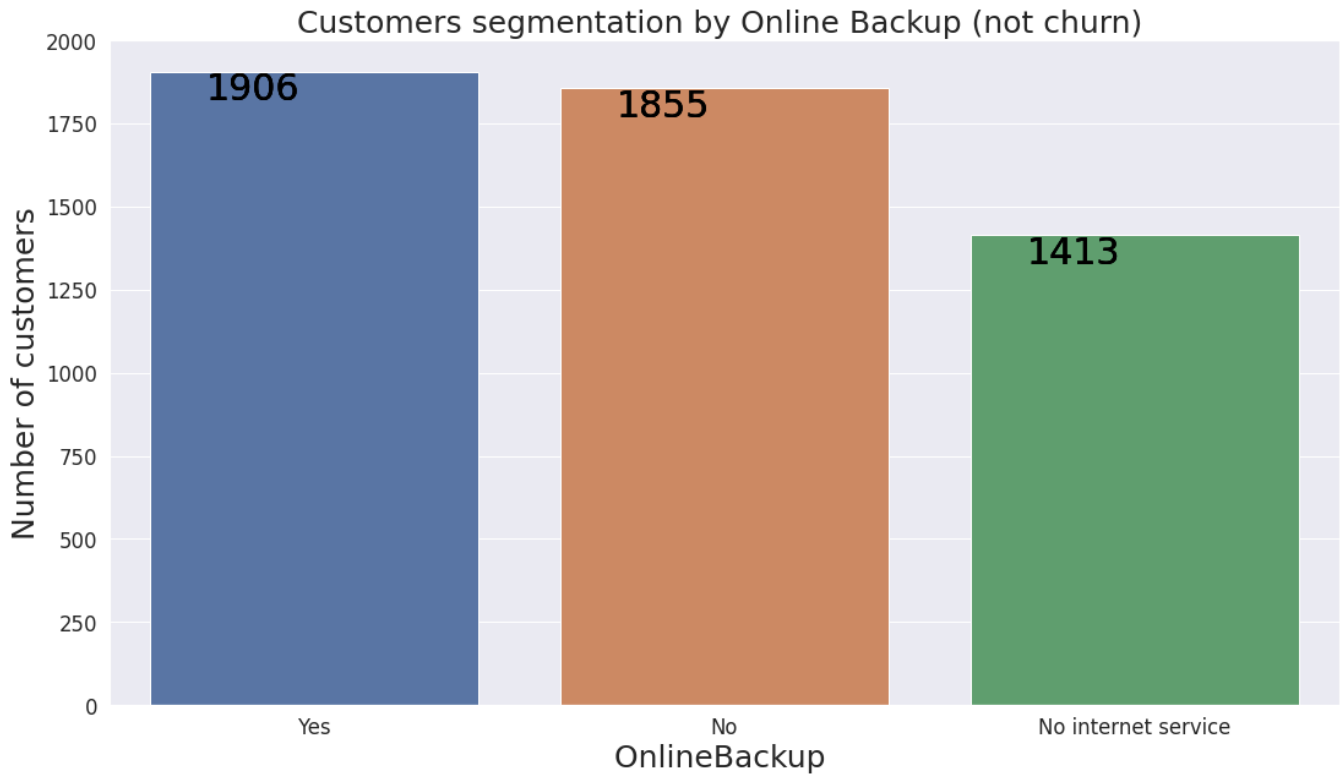

```
plt.figure(figsize=(18,11))
ax=sns.countplot(x='OnlineBackup',  data=ChurnData)
sns.set(font_scale=1.5)
ax.set_title('Customers segmentation by Online Backup (churn)  ' , fontsize = 25)
plt.xlabel('OnlineBackup ', fontsize=25)
plt.ylabel('Number of customers', fontsize=25)
plt.xticks(rotation='horizontal')
for p in ax.patches:
    for p in ax.patches:
        ax.annotate(format(p.get_height(), '.0f'),
                    (p.get_x()+0.25, p.get_height()), ha='center', va='top', color='black', s
```



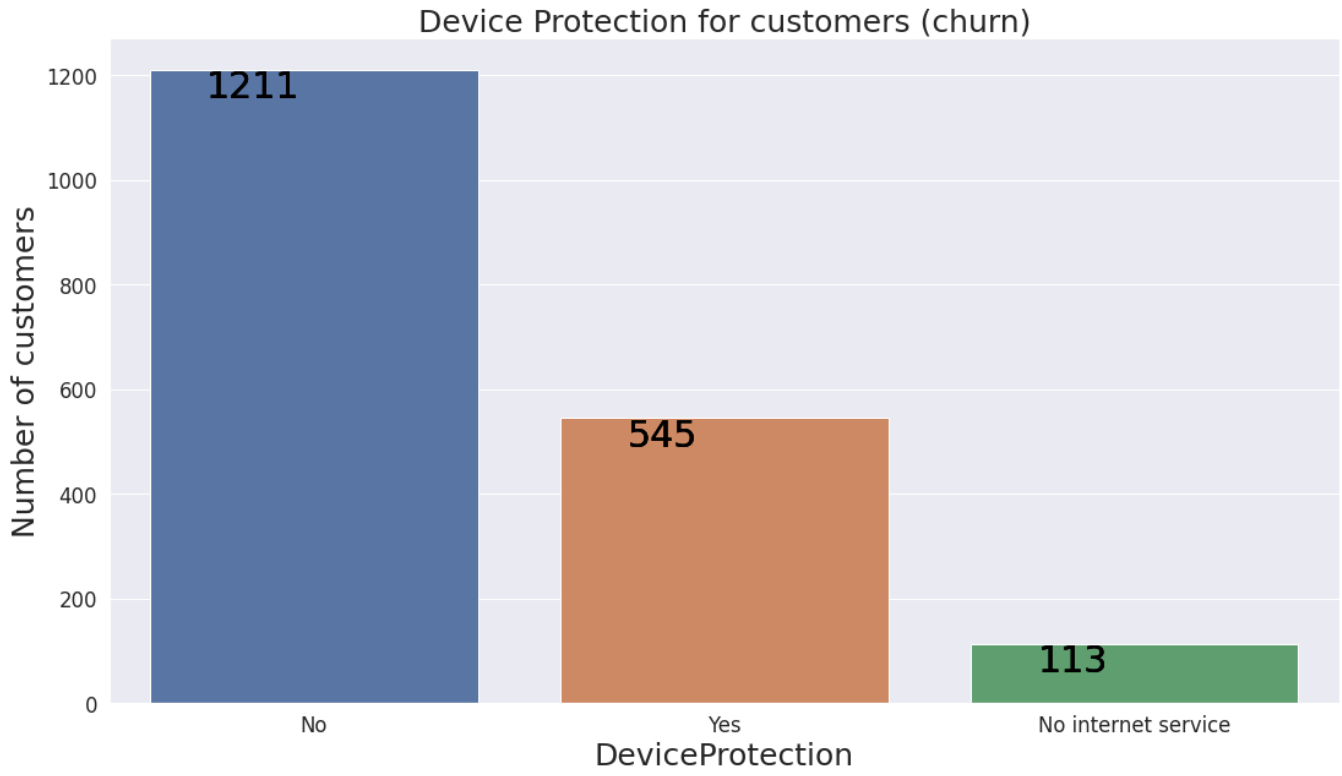

```
plt.figure(figsize=(18,11))
ax=sns.countplot(x='OnlineBackup',  data=ChurnData)
sns.set(font_scale=1.5)
ax.set_title('Customers segmentation by Online Backup (churn)  ' , fontsize = 25)
plt.xlabel('OnlineBackup ', fontsize=25)
plt.ylabel('Number of customers', fontsize=25)
plt.xticks(rotation='horizontal')

total = float(len(ChurnData))
for p in ax.patches:
    percentage = '{:.1f}%'.format(100 * p.get_height()/total)
    x = p.get_x() + p.get_width() / 2 - 0.1
    y = p.get_y() + p.get_height()
    ax.annotate(percentage, (x, y), size=12)
```



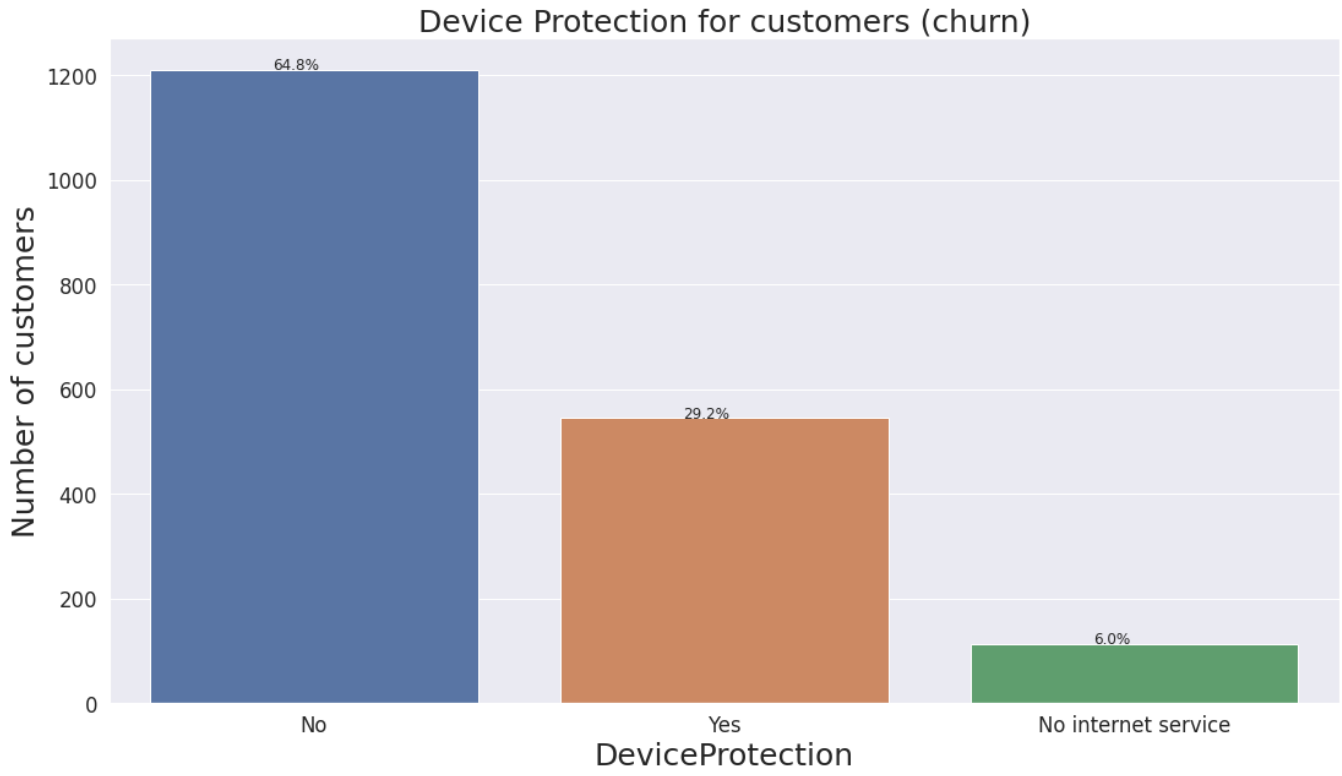

```
plt.figure(figsize=(18,10))
ax=sns.countplot(x='OnlineBackup',  data=NotChurnData)
sns.set(font_scale=1.5)
ax.set_title('Customers segmentation by Online Backup (not churn) ' , fontsize = 25)
plt.xlabel('OnlineBackup ', fontsize=25)
plt.ylabel('Number of customers', fontsize=25)
plt.xticks(rotation='horizontal')
for p in ax.patches:
    for p in ax.patches:
        ax.annotate(format(p.get_height(), '.0f'),
                    (p.get_x()+0.25, p.get_height()), ha='center', va='top', color='black', s
```



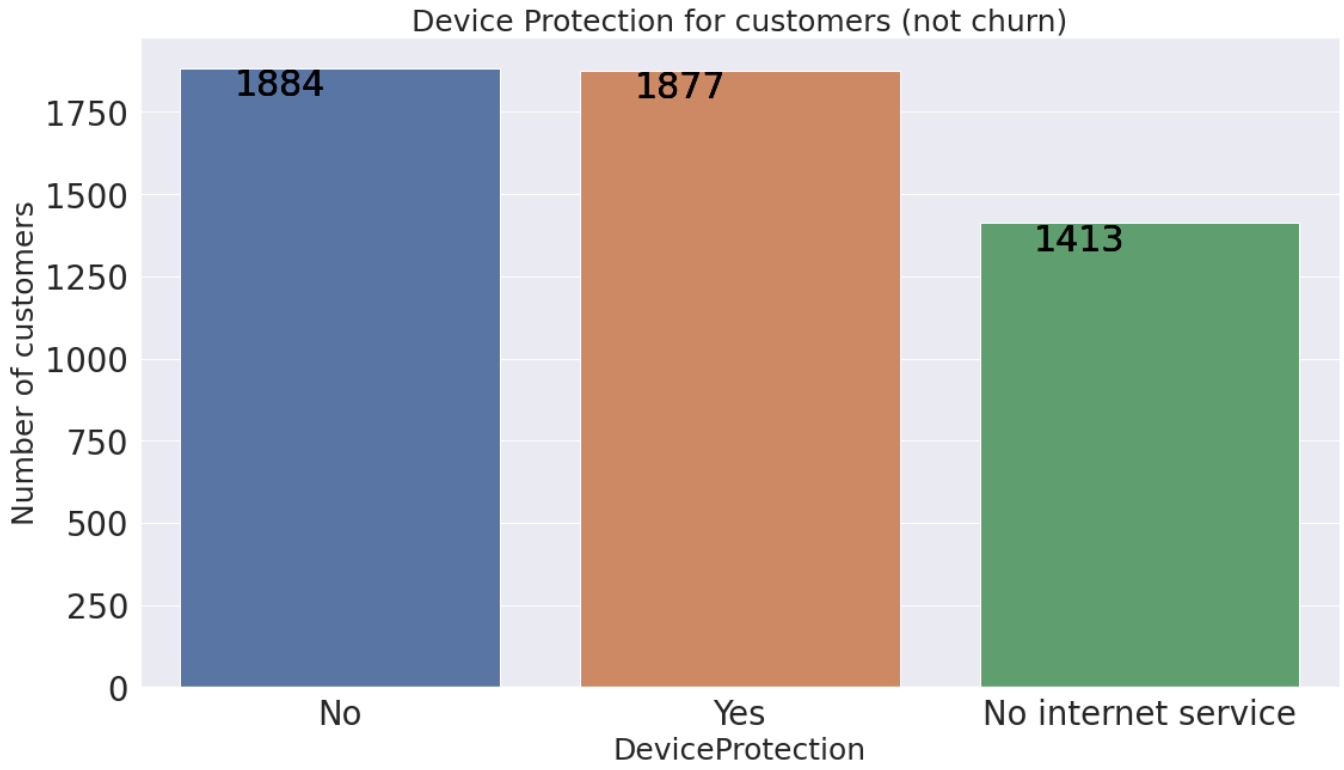

```
plt.figure(figsize=(18,10))
ax=sns.countplot(x='DeviceProtection', data=ChurnData)
sns.set(font_scale=2.5)
ax.set_title('Device Protection for customers (churn)' , fontsize = 25)
plt.xlabel('DeviceProtection', fontsize=25)
plt.ylabel('Number of customers', fontsize=25)
plt.xticks(rotation='horizontal')
for p in ax.patches:
    for p in ax.patches:
        ax.annotate(format(p.get_height(), '.0f'),
                    (p.get_x()+0.25, p.get_height()), ha='center', va='top', color='black', s
```



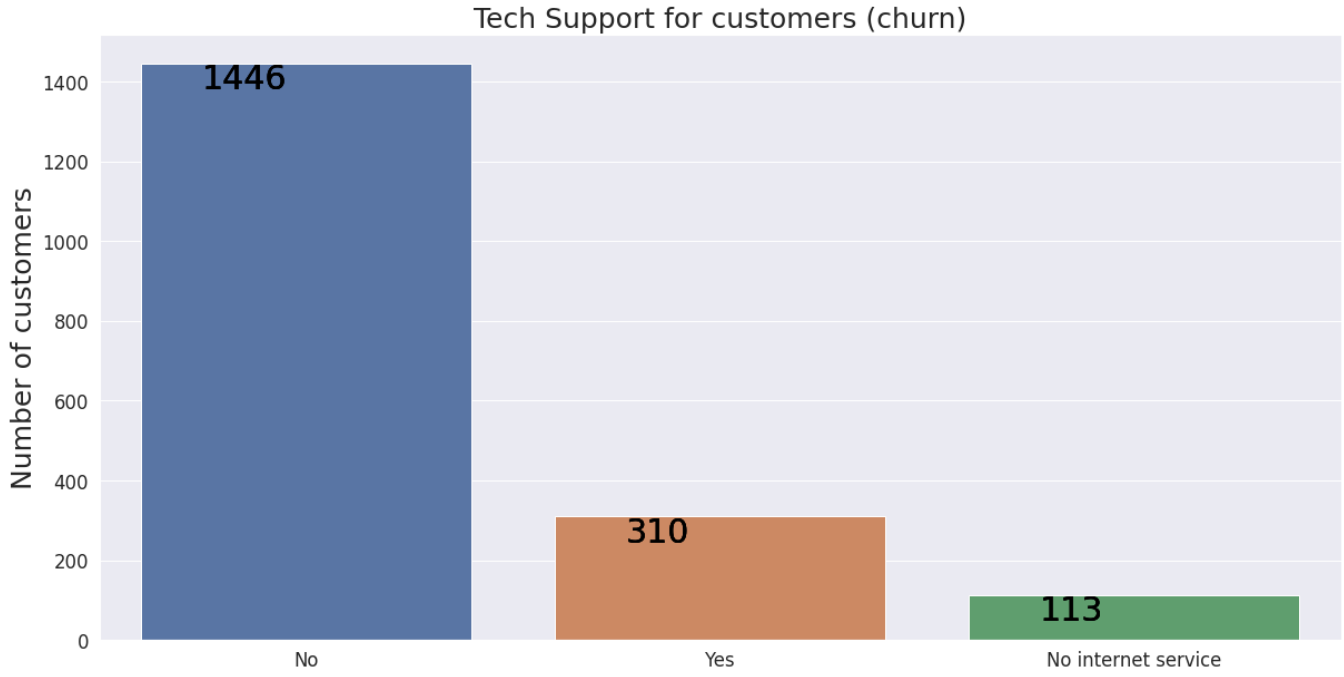

```
plt.figure(figsize=(18,10))
ax=sns.countplot(x='DeviceProtection', data=ChurnData)
sns.set(font_scale=2.5)
ax.set_title('Device Protection for customers (churn)' , fontsize = 25)
plt.xlabel('DeviceProtection', fontsize=25)
plt.ylabel('Number of customers', fontsize=25)
plt.xticks(rotation='horizontal')

total = float(len(ChurnData))
for p in ax.patches:
    percentage = '{:.1f}%'.format(100 * p.get_height()/total)
    x = p.get_x() + p.get_width() / 2 - 0.1
    y = p.get_y() + p.get_height()
    ax.annotate(percentage, (x, y), size=12)
```



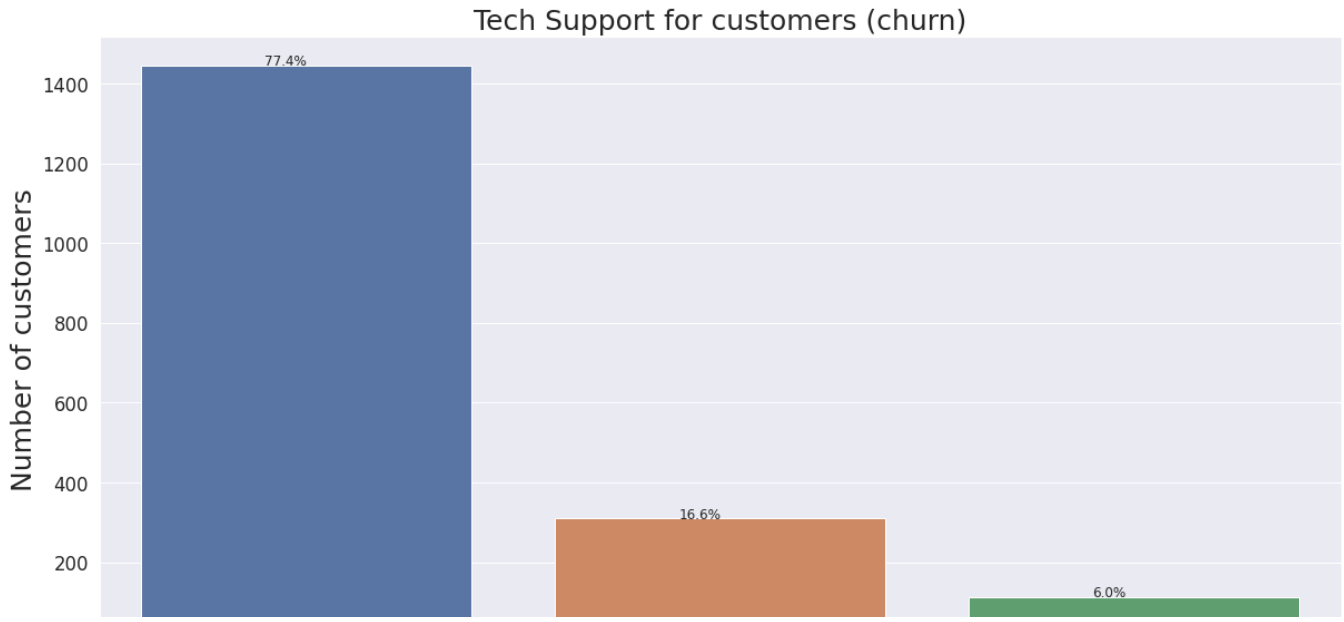

```
plt.figure(figsize=(18,10))
ax=sns.countplot(x='DeviceProtection', data=NotChurnData)
sns.set(font_scale=1.5)
ax.set_title('Device Protection for customers (not churn)' , fontsize = 25)
plt.xlabel('DeviceProtection', fontsize=25)
plt.ylabel('Number of customers', fontsize=25)
plt.xticks(rotation='horizontal')
for p in ax.patches:
    for p in ax.patches:
        ax.annotate(format(p.get_height(), '.0f'),
                    (p.get_x()+0.25, p.get_height()), ha='center', va='top', color='black', s
```



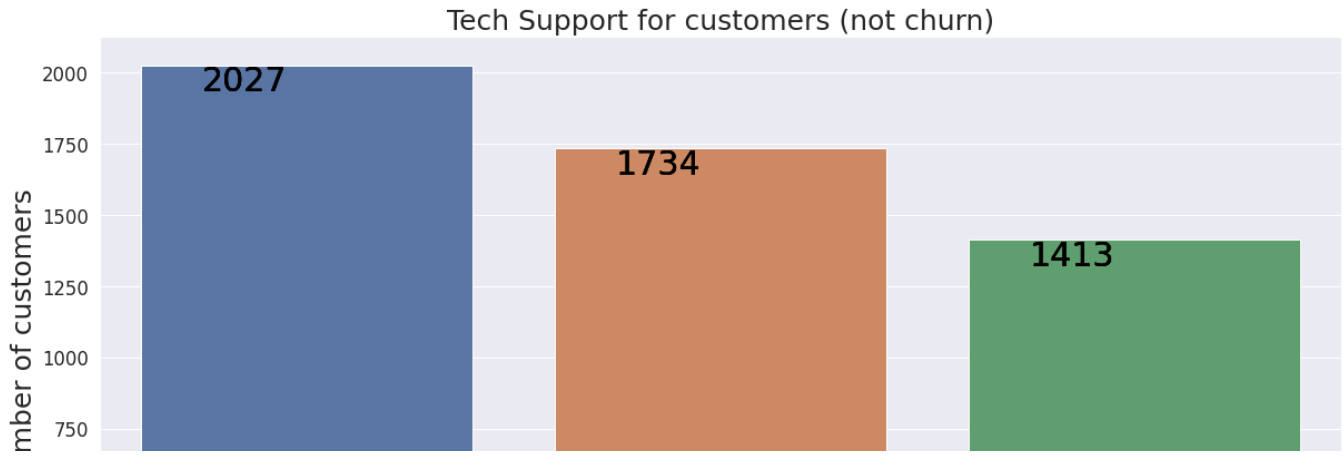

```
plt.figure(figsize=(20,10))
ax=sns.countplot(x='TechSupport',  data=ChurnData)
sns.set(font_scale=1.5)
ax.set_title('Tech Support for customers (churn)' , fontsize = 25)
plt.xlabel('TechSupport', fontsize=25)
plt.ylabel('Number of customers', fontsize=25)
plt.xticks(rotation='horizontal')
for p in ax.patches:
    for p in ax.patches:
        ax.annotate(format(p.get_height(), '.0f'),
                    (p.get_x()+0.25, p.get_height()), ha='center', va='top', color='black', s
```



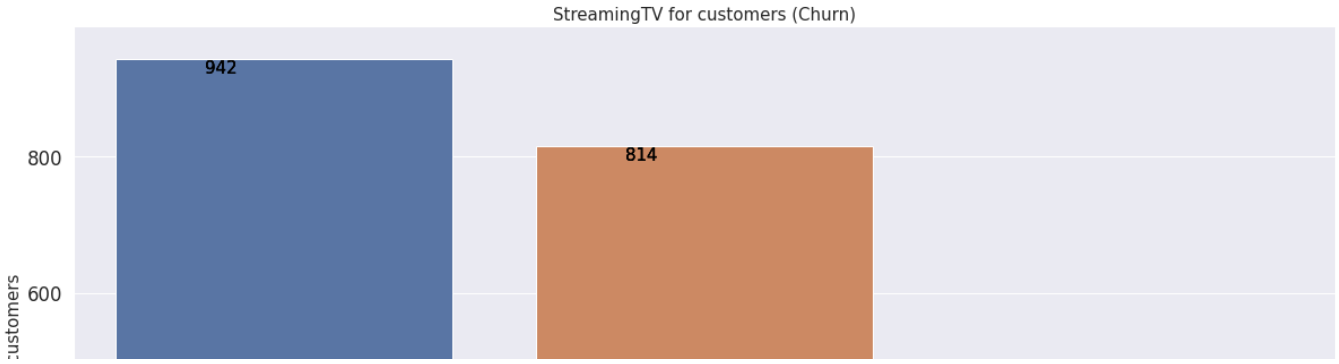

```
plt.figure(figsize=(20,10))
ax=sns.countplot(x='TechSupport',  data=ChurnData)
sns.set(font_scale=1.5)
ax.set_title('Tech Support for customers (churn)' , fontsize = 25)
plt.xlabel('TechSupport', fontsize=25)
plt.ylabel('Number of customers', fontsize=25)
plt.xticks(rotation='horizontal')

total = float(len(ChurnData))
for p in ax.patches:
    percentage = '{:.1f}%'.format(100 * p.get_height()/total)
    x = p.get_x() + p.get_width() / 2 - 0.1
    y = p.get_y() + p.get_height()
    ax.annotate(percentage, (x, y), size=12)
```



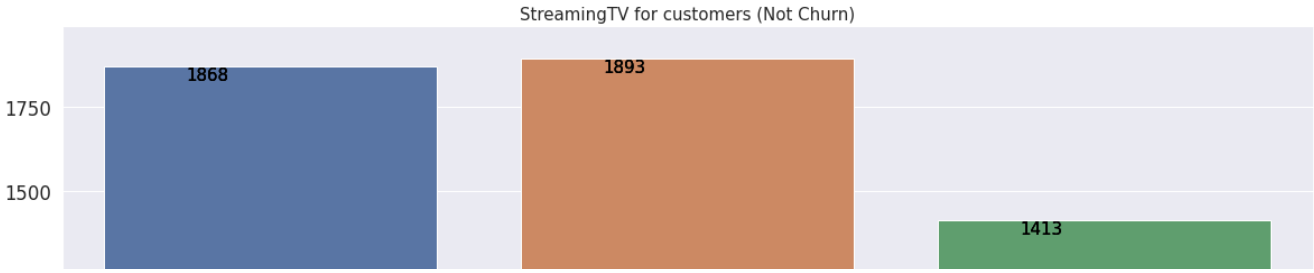

```
plt.figure(figsize=(20,10))
ax=sns.countplot(x='TechSupport',  data=NotChurnData)
sns.set(font_scale=1.5)
ax.set_title('Tech Support for customers (not churn)' , fontsize = 25)
plt.xlabel('TechSupport', fontsize=25)
plt.ylabel('Number of customers', fontsize=25)
plt.xticks(rotation='horizontal')
for p in ax.patches:
    for p in ax.patches:
        ax.annotate(format(p.get_height(), '.0f'),
                    (p.get_x()+0.25, p.get_height()), ha='center', va='top', color='black', s
```



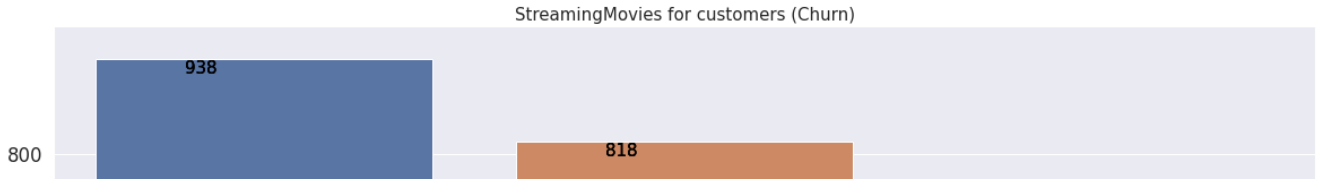

```
plt.figure(figsize=(20,11))
ax=sns.countplot(x='StreamingTV', data=ChurnData)
sns.set(font_scale=1.5)
ax.set_title('StreamingTV for customers (Churn)' , fontsize = 15)
plt.xlabel('StreamingTV', fontsize=15)
plt.ylabel('Number of customers', fontsize=15)
plt.xticks(rotation='horizontal')
for p in ax.patches:
    for p in ax.patches:
        ax.annotate(format(p.get_height(), '.0f'),
                    (p.get_x()+0.25, p.get_height()), ha='center', va='top', color='black', s
```



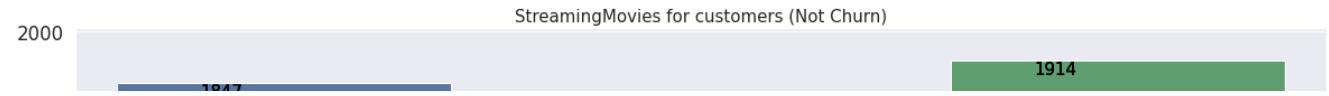

```
plt.figure(figsize=(20,11))
ax=sns.countplot(x='StreamingTV', data=NotChurnData)
sns.set(font_scale=1.5)
ax.set_title('StreamingTV for customers (Not Churn)' , fontsize = 15)
plt.xlabel('StreamingTV', fontsize=15)
plt.ylabel('Number of customers', fontsize=15)
plt.xticks(rotation='horizontal')
for p in ax.patches:
    for p in ax.patches:
        ax.annotate(format(p.get_height(), '.0f'),
                    (p.get_x()+0.25, p.get_height()), ha='center', va='top', color='black', s
```



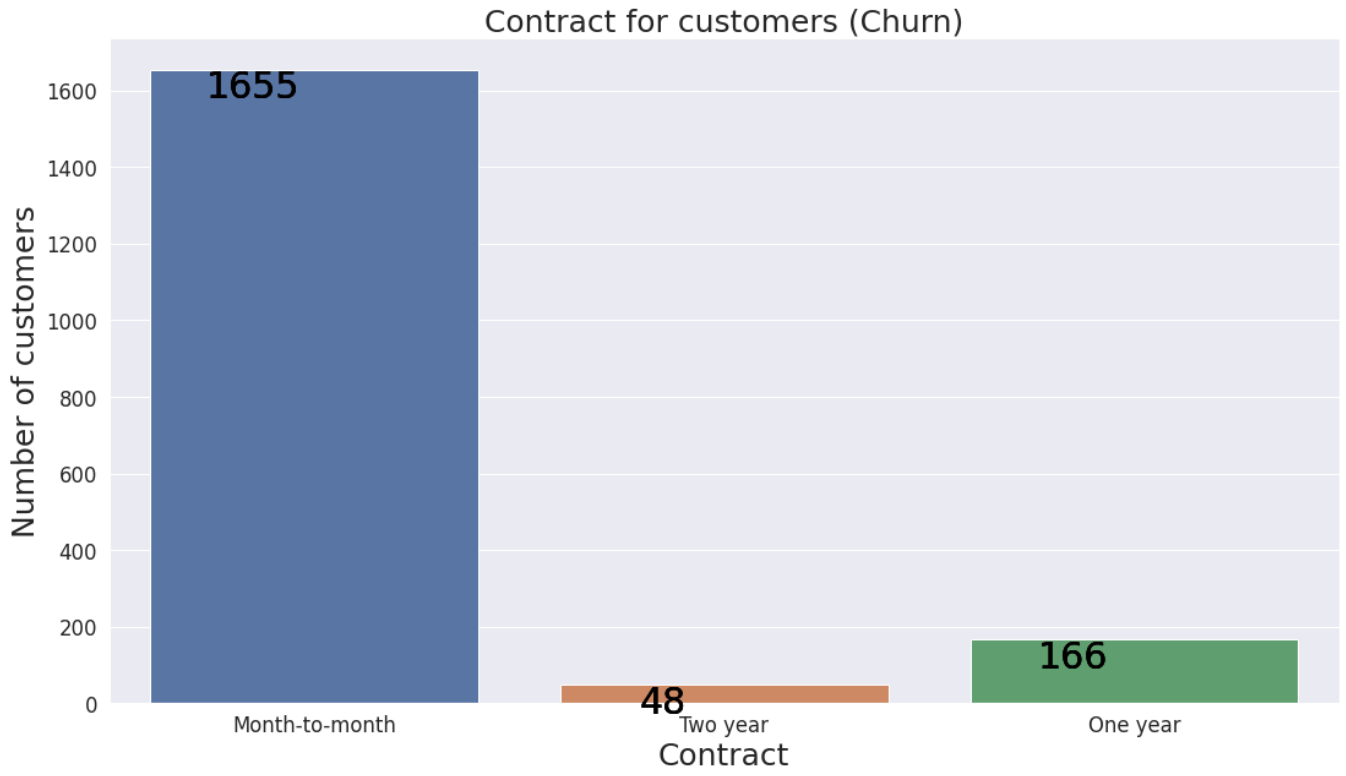

```
plt.figure(figsize=(20,11))
ax=sns.countplot(x='StreamingMovies', data=ChurnData)
sns.set(font_scale=1.5)
ax.set_title('StreamingMovies for customers (Churn)' , fontsize = 15)
plt.xlabel('StreamingMovies', fontsize=15)
plt.ylabel('Number of customers', fontsize=15)
plt.xticks(rotation='horizontal')
for p in ax.patches:
    for p in ax.patches:
        ax.annotate(format(p.get_height(), '.0f'),
                    (p.get_x()+0.25, p.get_height()), ha='center', va='top', color='black', s
```



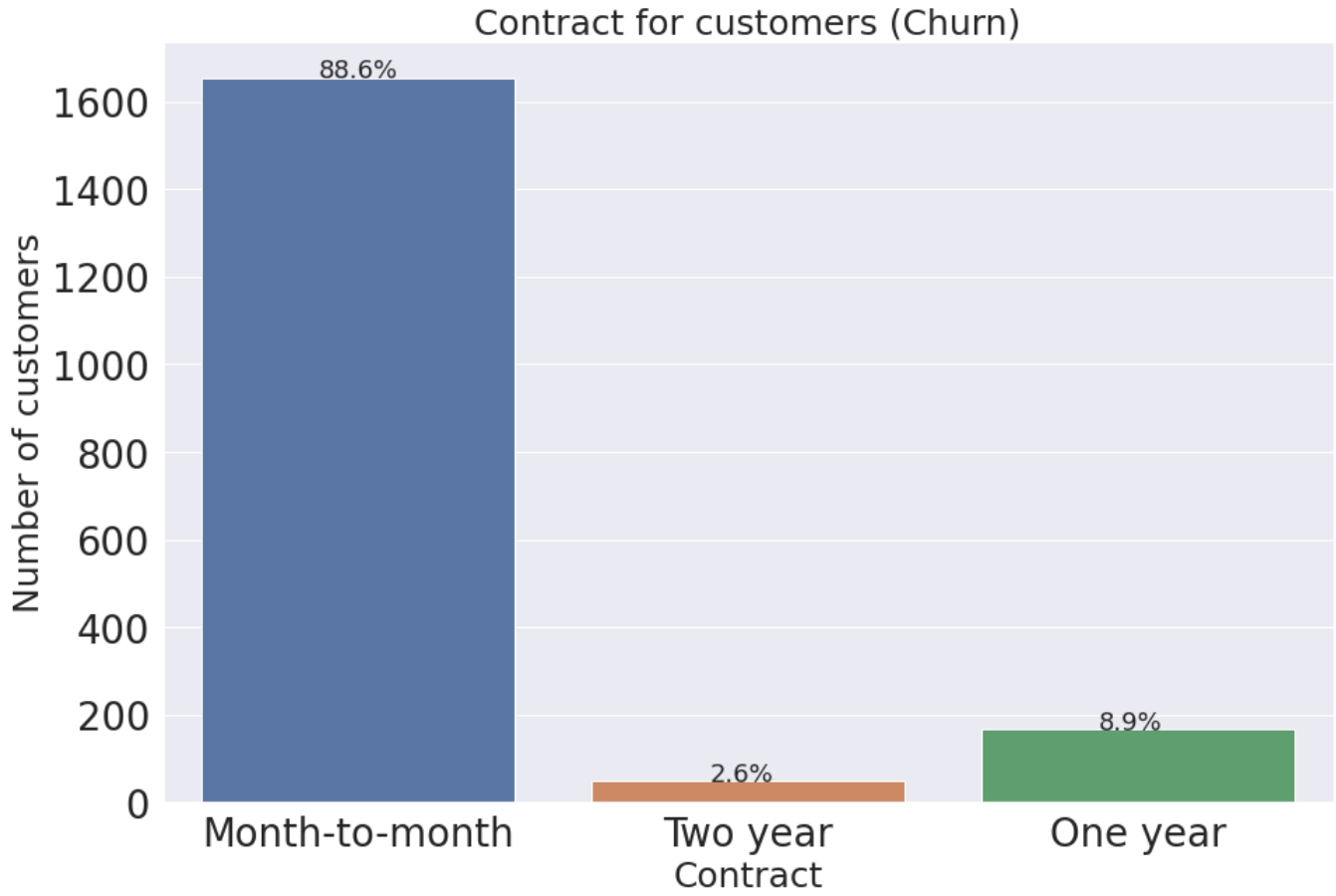

```
plt.figure(figsize=(20,11))
ax=sns.countplot(x='StreamingMovies', data=NotChurnData)
sns.set(font_scale=1.5)
ax.set_title('StreamingMovies for customers (Not Churn)' , fontsize = 15)
plt.xlabel('StreamingMovies', fontsize=15)
plt.ylabel('Number of customers', fontsize=15)
plt.xticks(rotation='horizontal')
for p in ax.patches:
    for p in ax.patches:
        ax.annotate(format(p.get_height(), '.0f'),
                    (p.get_x()+0.25, p.get_height()), ha='center', va='top', color='black', s
```



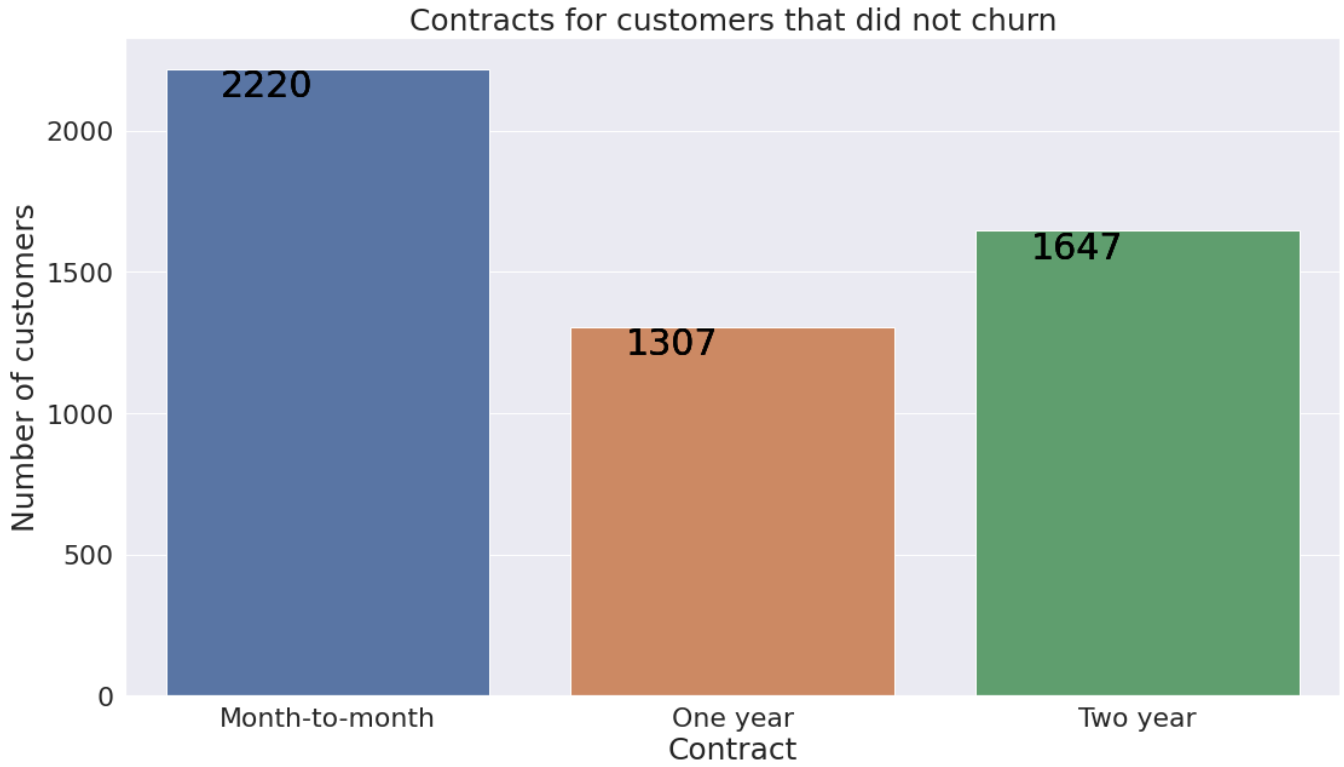

```
plt.figure(figsize=(18,10))
ax=sns.countplot(x='Contract', data=ChurnData)
sns.set(font_scale=2.0)
ax.set_title('Contract for customers (Churn)' , fontsize = 25)
plt.xlabel('Contract', fontsize=25)
plt.ylabel('Number of customers', fontsize=25)
plt.xticks(rotation='horizontal')
for p in ax.patches:
    for p in ax.patches:
        ax.annotate(format(p.get_height(), '.0f'),
                    (p.get_x()+0.25, p.get_height()), ha='center', va='top', color='black', s
```



```
plt.figure(figsize=(15,10))
ax=sns.countplot(x='Contract', data=ChurnData)
sns.set(font_scale=2.5)
ax.set_title('Contract for customers (Churn)' , fontsize = 25)
plt.xlabel('Contract', fontsize=25)
plt.ylabel('Number of customers', fontsize=25)
plt.xticks(rotation='horizontal')

total = float(len(ChurnData))
for p in ax.patches:
    percentage = '{:.1f}%'.format(100 * p.get_height()/total)
    x = p.get_x() + p.get_width() / 2 - 0.1
    y = p.get_y() + p.get_height()
    ax.annotate(percentage, (x, y), size=18)
```

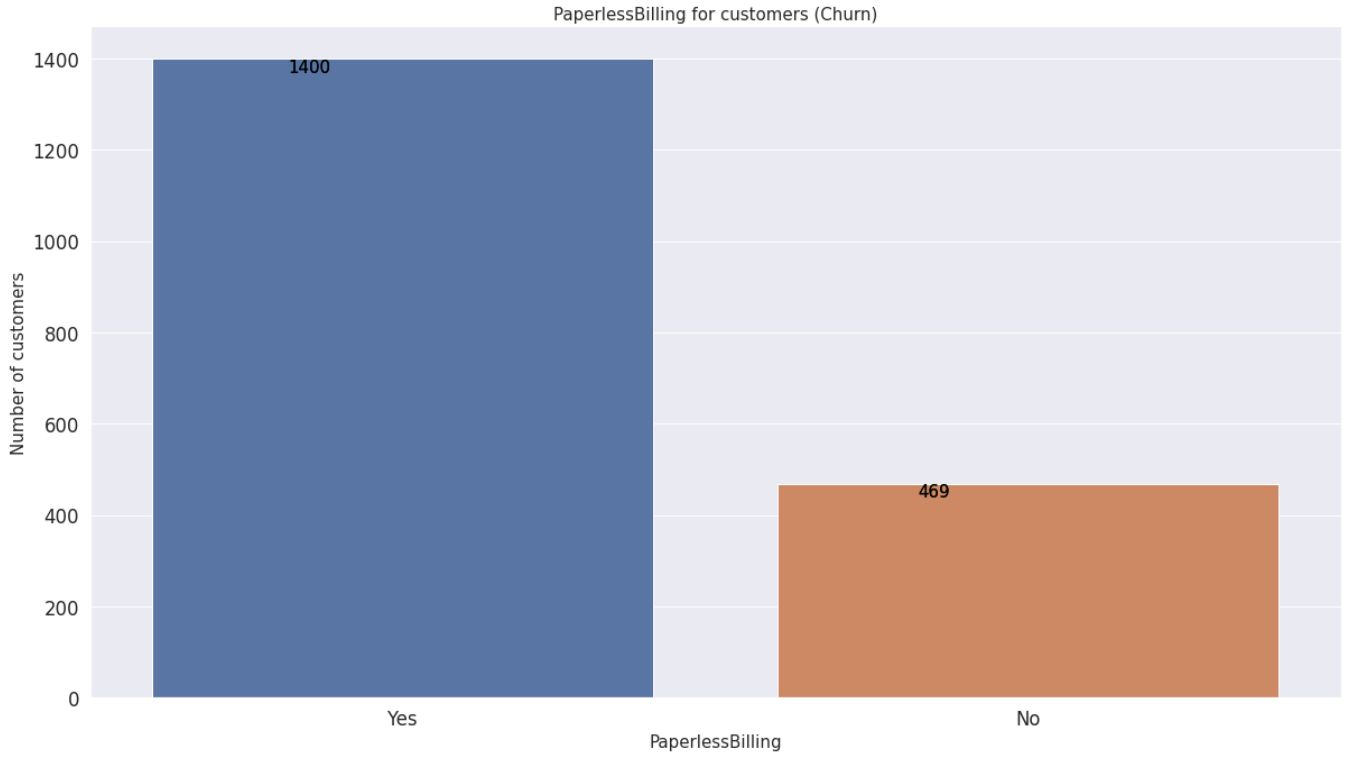


```
plt.figure(figsize=(18,10))
ax=sns.countplot(x='Contract', data=NotChurnData)
sns.set(font_scale=1.5)
ax.set_title('Contracts for customers that did not churn' , fontsize = 25)
plt.xlabel('Contract', fontsize=25)
plt.ylabel('Number of customers', fontsize=25)
plt.xticks(rotation='horizontal')
for p in ax.patches:
    for p in ax.patches:
        ax.annotate(format(p.get_height(), '.0f'),
                    (p.get_x()+0.25, p.get_height()), ha='center', va='top', color='black', s
```



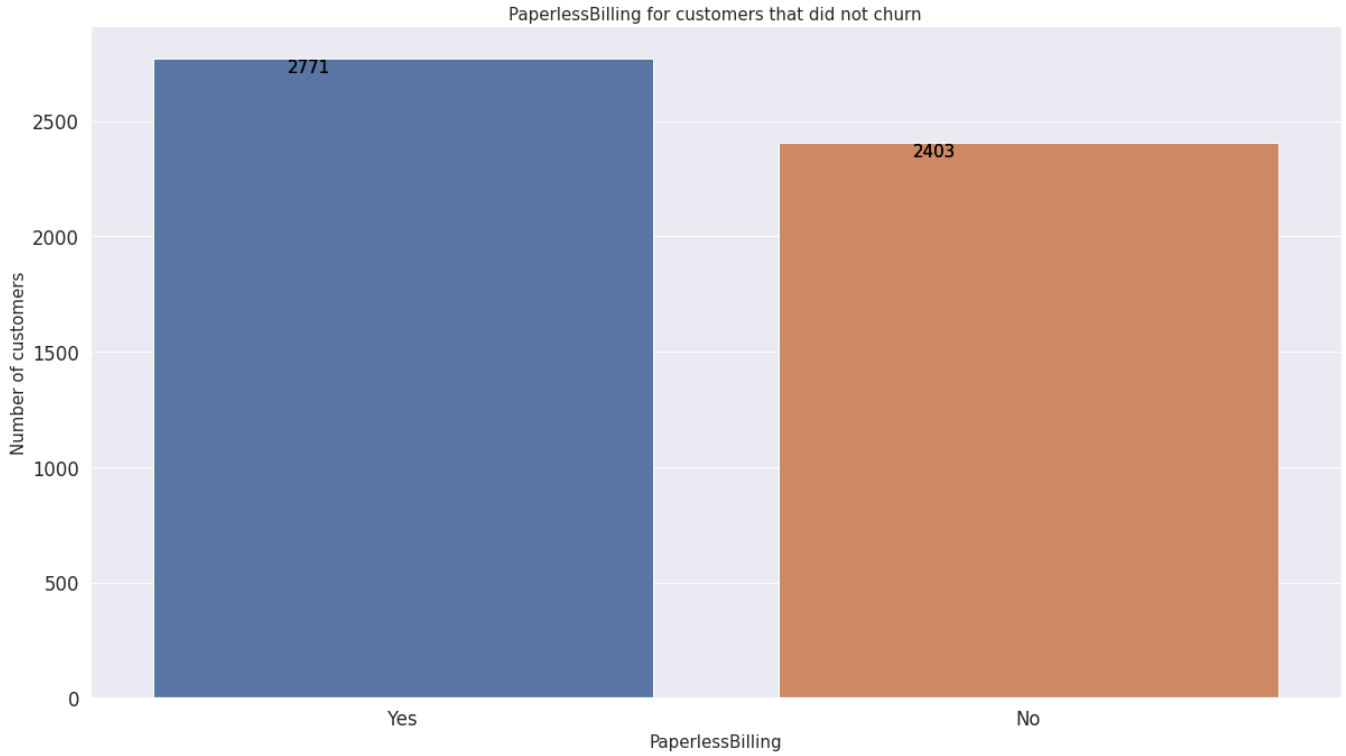

```
plt.figure(figsize=(20,11))
ax=sns.countplot(x='PaperlessBilling', data=ChurnData)
sns.set(font_scale=1.5)
ax.set_title('PaperlessBilling for customers (Churn)' , fontsize = 15)
```

```
plt.xlabel('PaperlessBilling', fontsize=15)
plt.ylabel('Number of customers', fontsize=15)
plt.xticks(rotation='horizontal')
for p in ax.patches:
    for p in ax.patches:
        ax.annotate(format(p.get_height(), '.0f'),
                    (p.get_x()+0.25, p.get_height()), ha='center', va='top', color='black', s
```



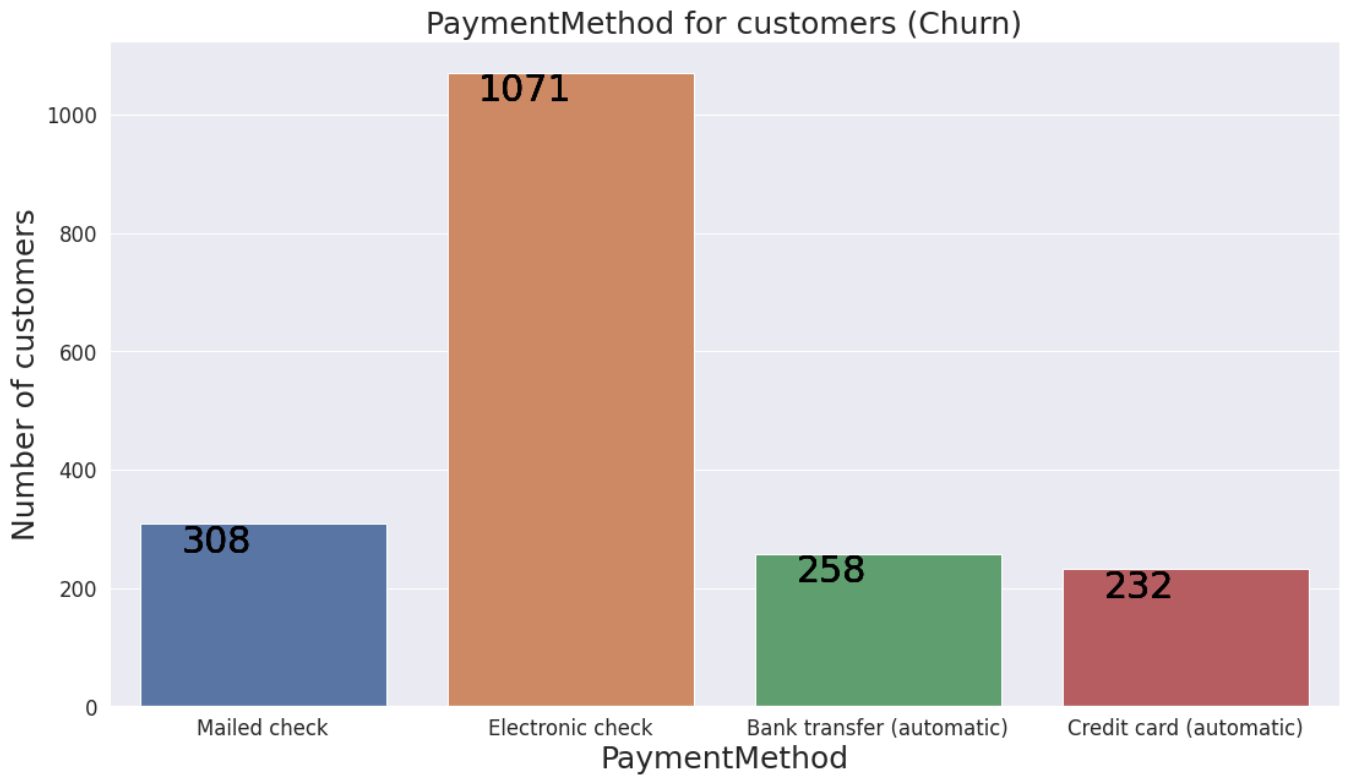

```
plt.figure(figsize=(20,11))
ax=sns.countplot(x='PaperlessBilling', data=NotChurnData)
sns.set(font_scale=1.5)
ax.set_title('PaperlessBilling for customers that did not churn' , fontsize = 15)
plt.xlabel('PaperlessBilling', fontsize=15)
plt.ylabel('Number of customers', fontsize=15)
```

```
plt.xticks(rotation='horizontal')
for p in ax.patches:
    for p in ax.patches:
        ax.annotate(format(p.get_height(), '.0f'),
                    (p.get_x()+0.25, p.get_height()), ha='center', va='top', color='black', s
```

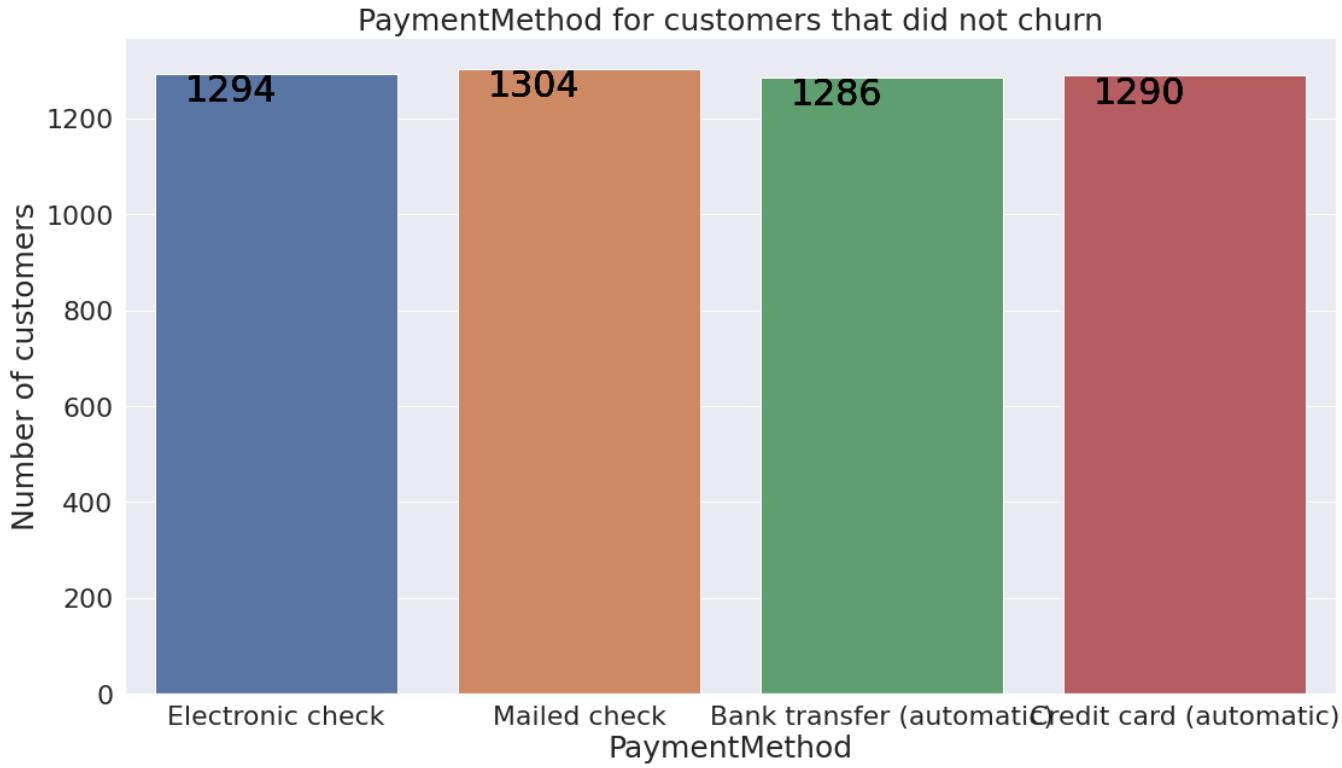



```
plt.figure(figsize=(18,10))
ax=sns.countplot(x='PaymentMethod',data=ChurnData)
sns.set(font_scale=2.0)
ax.set_title('PaymentMethod for customers (Churn)' , fontsize = 25)
plt.xlabel('PaymentMethod', fontsize=25)
plt.ylabel('Number of customers', fontsize=25)
plt.xticks(rotation='horizontal')
for p in ax.patches:
```

```
    for p in ax.patches:
        ax.annotate(format(p.get_height(), '.0f'),
                    (p.get_x()+0.25, p.get_height()), ha='center', va='top', color='black', s
```



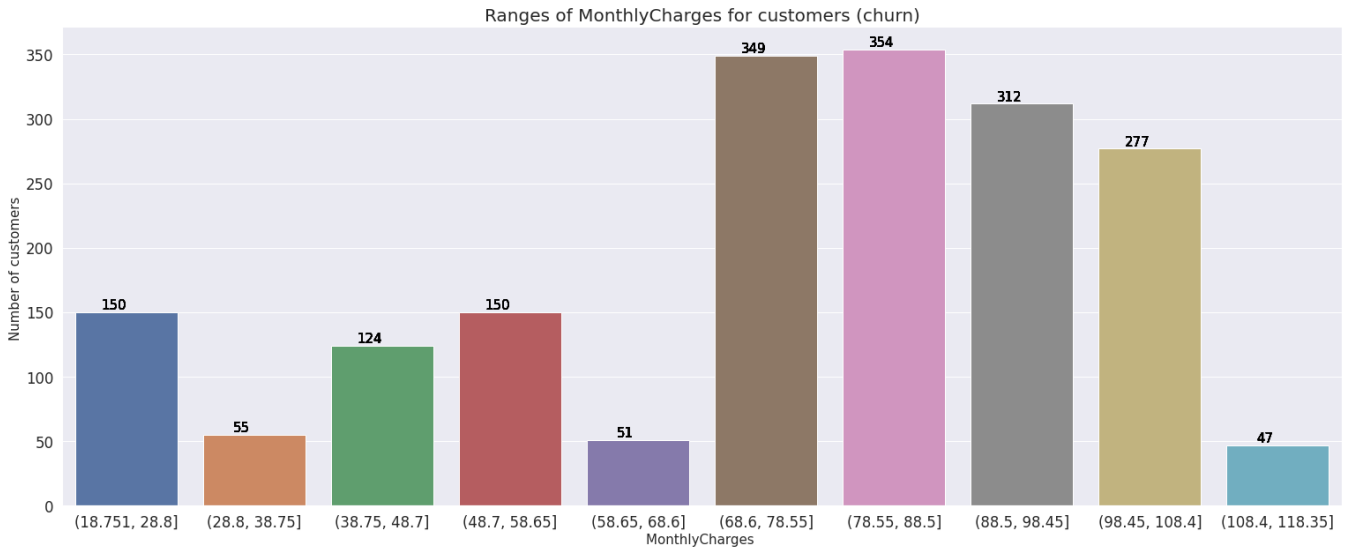

```
plt.figure(figsize=(18,10))
ax=sns.countplot(x='PaymentMethod',data=NotChurnData)
sns.set(font_scale=1.5)
ax.set_title('PaymentMethod for customers that did not churn' , fontsize = 25)
plt.xlabel('PaymentMethod', fontsize=25)
plt.ylabel('Number of customers', fontsize=25)
plt.xticks(rotation='horizontal')
for p in ax.patches:
    for p in ax.patches:
        ax.annotate(format(p.get_height(), '.0f'),
                    (p.get_x()+0.25, p.get_height()), ha='center', va='top', color='black', s
```



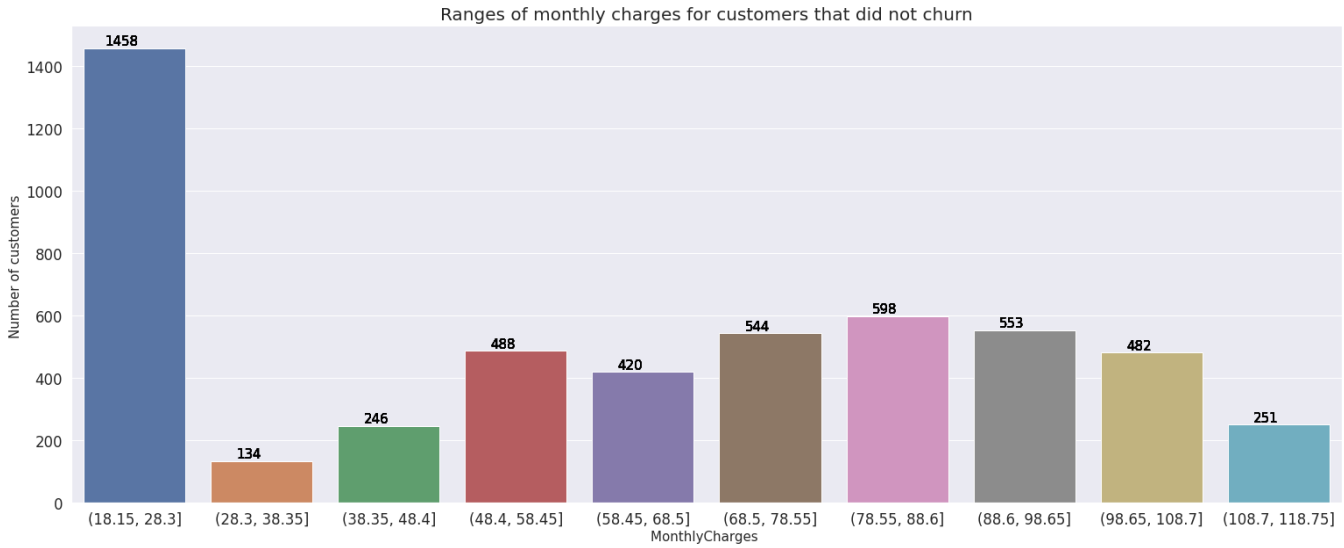

```
# To put the monthlycharges in bins
binsB = pd.cut(ChurnData['MonthlyCharges'], 10)
bins2 = pd.cut(NotChurnData['MonthlyCharges'], 10)
```

```
plt.figure(figsize=(26,10))
sns.set(font_scale=1.5)
ax=sns.countplot(x=binsB)
ax.set_title('Ranges of MonthlyCharges for customers (churn)' , fontsize = 20)
plt.xlabel('MonthlyCharges ', fontsize=15)
plt.ylabel('Number of customers ', fontsize=15)
plt.xticks(rotation='horizontal')
for p in ax.patches:
    for p in ax.patches:
```

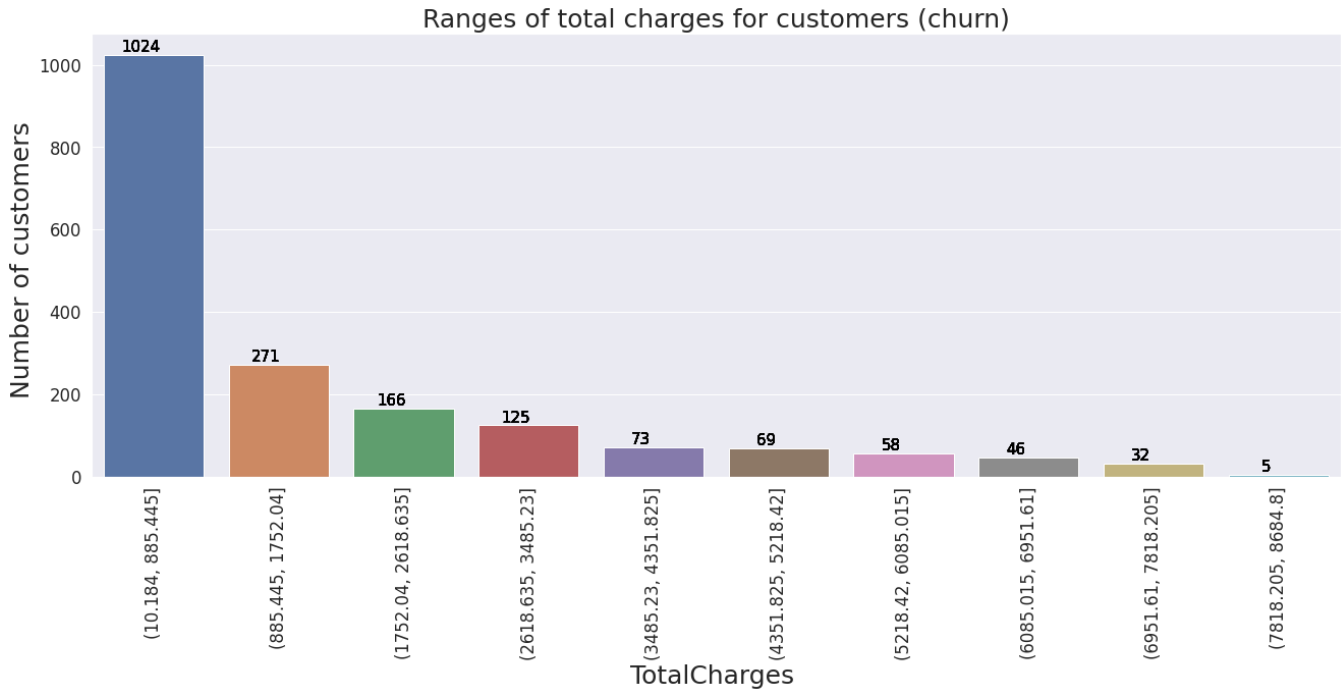
```
        ax.annotate(format(p.get_height(), '.0f'),
                    (p.get_x()+0.3, p.get_height()), ha='center', va='bottom', color='black',
```



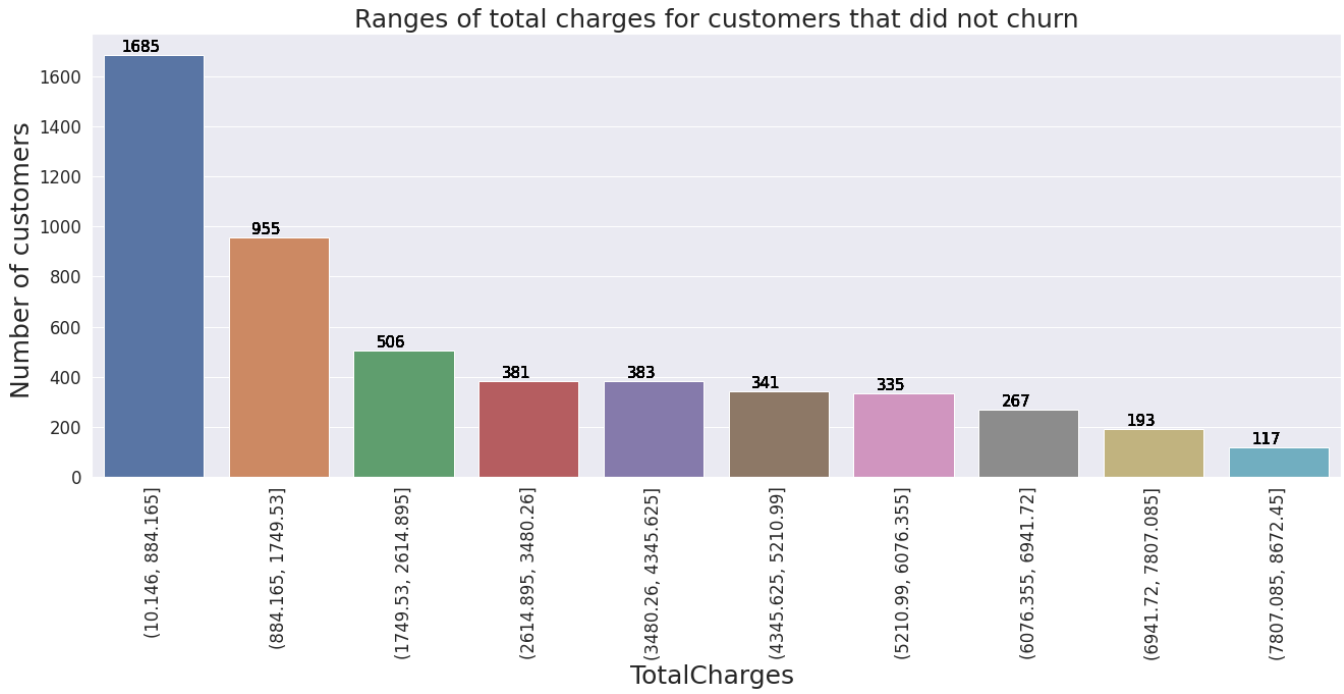

```
plt.figure(figsize=(26,10))
sns.set(font_scale=1.5)
ax=sns.countplot(x=bins2)
ax.set_title('Ranges of monthly charges for customers that did not churn' , fontsize = 20)
plt.xlabel('MonthlyCharges ', fontsize=15)
plt.ylabel('Number of customers ', fontsize=15)
plt.xticks(rotation='horizontal')
for p in ax.patches:
    for p in ax.patches:
        ax.annotate(format(p.get_height(), '.0f'),
                    (p.get_x()+0.3, p.get_height()), ha='center', va='bottom', color='black',
```




```
# Total charges in bins
binsC = pd.cut(ChurnData['TotalCharges'], 10)
bins3 = pd.cut(NotChurnData['TotalCharges'], 10)


plt.figure(figsize=(22,8))
sns.set(font_scale=1.5)
ax=sns.countplot(x=binsC)
ax.set_title('Ranges of total charges for customers (churn)' , fontsize = 25)
plt.xlabel('TotalCharges ', fontsize=25)
plt.ylabel('Number of customers ', fontsize=25)
plt.xticks(rotation='vertical')
for p in ax.patches:
    for p in ax.patches:
        ax.annotate(format(p.get_height(), '.0f'),
                    (p.get_x()+0.3, p.get_height()), ha='center', va='bottom', color='black',
```




```
plt.figure(figsize=(22,8))
sns.set(font_scale=1.5)
ax=sns.countplot(x=bins3)
ax.set_title('Ranges of total charges for customers that did not churn' , fontsize = 25)
plt.xlabel('TotalCharges ', fontsize=25)
plt.ylabel('Number of customers ', fontsize=25)
plt.xticks(rotation='vertical')
for p in ax.patches:
    for p in ax.patches:
        ax.annotate(format(p.get_height(), '.0f'),
                    (p.get_x()+0.3, p.get_height()), ha='center', va='bottom', color='black',
```




```
# CLUSTERING TECHNIQUE TO CONTINUE FROM HERE

df.head()
```

	customerID	gender	SeniorCitizen	Partner	Dependents	tenure	PhoneService	Multipl
0	7590-VHVEG	Female	0	Yes	No	1	No	No
1	5575-GNVDE	Male	0	No	No	34	Yes	
2	3668-QPYBK	Male	0	No	No	2	Yes	

CPUCW

```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 7043 entries, 0 to 7042
Data columns (total 21 columns):
 #   Column            Non-Null Count  Dtype  
---  ------            --------------  -----  
 0   customerID        7043 non-null   object 
 1   gender            7043 non-null   object 
 2   SeniorCitizen     7043 non-null   int64  
 3   Partner           7043 non-null   object 
 4   Dependents        7043 non-null   object 
 5   tenure            7043 non-null   int64  
 6   PhoneService      7043 non-null   object 
 7   MultipleLines     7043 non-null   object 
 8   InternetService   7043 non-null   object 
 9   OnlineSecurity    7043 non-null   object 
 10  OnlineBackup      7043 non-null   object 
 11  DeviceProtection  7043 non-null   object 
 12  TechSupport       7043 non-null   object 
 13  StreamingTV       7043 non-null   object 
 14  StreamingMovies   7043 non-null   object 
 15  Contract          7043 non-null   object 
 16  PaperlessBilling  7043 non-null   object 
 17  PaymentMethod     7043 non-null   object 
 18  MonthlyCharges    7043 non-null   float64
 19  TotalCharges      7032 non-null   float64
 20  Churn             7043 non-null   object 
dtypes: float64(2), int64(2), object(17)
memory usage: 1.1+ MB
```

```
df.nunique()
```

```
customerID          7043
gender                 2
SeniorCitizen          2
Partner                2
Dependents             2
tenure                73
PhoneService           2
MultipleLines          3
```

```
InternetService        3
OnlineSecurity         3
OnlineBackup           3
DeviceProtection       3
TechSupport            3
StreamingTV            3
StreamingMovies        3
Contract               3
PaperlessBilling       2
PaymentMethod          4
MonthlyCharges      1585
TotalCharges        6530
Churn                  2
dtype: int64
```

```
df.describe()
```

	SeniorCitizen	tenure	MonthlyCharges	TotalCharges
count	7043.000000	7043.000000	7043.000000	7032.000000
mean	0.162147	32.371149	64.761692	2283.300441
std	0.368612	24.559481	30.090047	2266.771362
min	0.000000	0.000000	18.250000	18.800000
25%	0.000000	9.000000	35.500000	401.450000
50%	0.000000	29.000000	70.350000	1397.475000
75%	0.000000	55.000000	89.850000	3794.737500
max	1.000000	72.000000	118.750000	8684.800000

```
df.isna().sum()
```

```
customerID           0
gender               0
SeniorCitizen        0
Partner              0
Dependents           0
tenure               0
PhoneService         0
MultipleLines        0
InternetService      0
OnlineSecurity       0
OnlineBackup         0
DeviceProtection     0
TechSupport          0
StreamingTV          0
StreamingMovies      0
Contract             0
PaperlessBilling     0
PaymentMethod        0
```

```
MonthlyCharges       0
TotalCharges        11
Churn                0
dtype: int64
```

```
# To drop missing values
df= df.dropna()
```

```
data3 =df
```

```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 7032 entries, 0 to 7042
Data columns (total 21 columns):
 #   Column            Non-Null Count  Dtype  
---  ------            --------------  -----  
 0   customerID        7032 non-null   object 
 1   gender            7032 non-null   object 
 2   SeniorCitizen     7032 non-null   int64  
 3   Partner           7032 non-null   object 
 4   Dependents        7032 non-null   object 
 5   tenure            7032 non-null   int64  
 6   PhoneService      7032 non-null   object 
 7   MultipleLines     7032 non-null   object 
 8   InternetService   7032 non-null   object 
 9   OnlineSecurity    7032 non-null   object 
 10  OnlineBackup      7032 non-null   object 
 11  DeviceProtection  7032 non-null   object 
 12  TechSupport       7032 non-null   object 
 13  StreamingTV       7032 non-null   object 
 14  StreamingMovies   7032 non-null   object 
 15  Contract          7032 non-null   object 
 16  PaperlessBilling  7032 non-null   object 
 17  PaymentMethod     7032 non-null   object 
 18  MonthlyCharges    7032 non-null   float64
 19  TotalCharges      7032 non-null   float64
 20  Churn             7032 non-null   object 
dtypes: float64(2), int64(2), object(17)
memory usage: 1.2+ MB
```

```
dataframe =df
```

```
#Encoding
# encode categorical variables
le = LabelEncoder()
```

```
# loop through each column in the dataframe
for column in dataframe.columns:
    # check if the column has object datatype (i.e. categorical)
    if dataframe[column].dtype == 'object':
        # use LabelEncoder to encode the categorical values
        dataframe[column] = le.fit_transform(dataframe[column])
```

```
<ipython-input-219-4abe45ab18b9>:6: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-docs/stable/u
  dataframe[column] = le.fit_transform(dataframe[column])
<ipython-input-219-4abe45ab18b9>:6: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-docs/stable/u
  dataframe[column] = le.fit_transform(dataframe[column])
<ipython-input-219-4abe45ab18b9>:6: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-docs/stable/u
  dataframe[column] = le.fit_transform(dataframe[column])
<ipython-input-219-4abe45ab18b9>:6: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-docs/stable/u
  dataframe[column] = le.fit_transform(dataframe[column])
<ipython-input-219-4abe45ab18b9>:6: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-docs/stable/u
  dataframe[column] = le.fit_transform(dataframe[column])
<ipython-input-219-4abe45ab18b9>:6: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-docs/stable/u
  dataframe[column] = le.fit_transform(dataframe[column])
<ipython-input-219-4abe45ab18b9>:6: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead
```

```
See the caveats in the documentation: https://pandas.pydata.org/pandas-docs/stable/u
  dataframe[column] = le.fit_transform(dataframe[column])
<ipython-input-219-4abe45ab18b9>:6: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-docs/stable/u
  dataframe[column] = le.fit_transform(dataframe[column])
<ipython-input-219-4abe45ab18b9>:6: SettingWithCopyWarning:
```

```
dataframe.head()
```

	customerID	gender	SeniorCitizen	Partner	Dependents	tenure	PhoneService	Multipl
0	5365	0	0	1	0	1	0	
1	3953	1	0	0	0	34	1	
2	2558	1	0	0	0	2	1	
3	5524	1	0	0	0	45	0	
4	6500	0	0	0	0	2	1	

5 rows × 21 columns

```
dataframe = dataframe.drop('customerID', axis=1)
```

```
dataframe = dataframe.drop('Churn', axis=1)
```

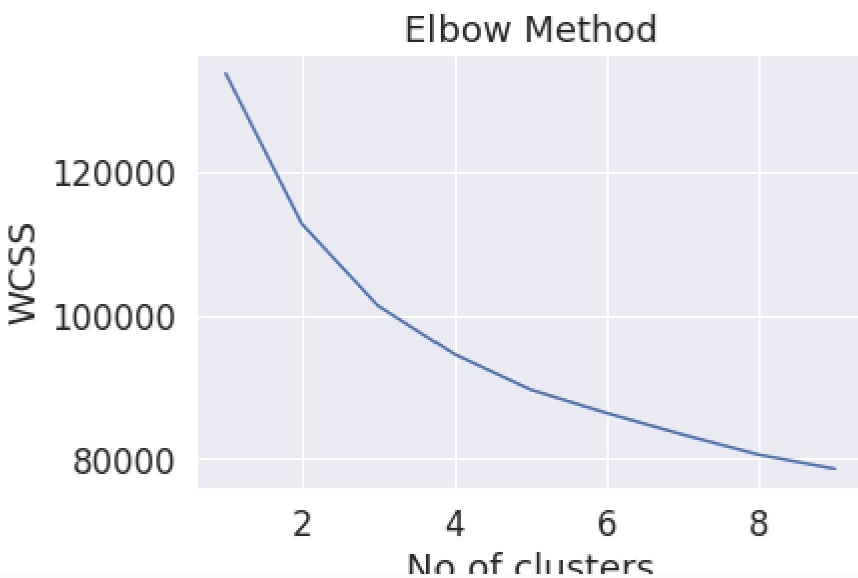
```
X = dataframe.values
```

```
standardizer = StandardScaler()
X = standardizer.fit_transform(X)
```

```
from sklearn.cluster import KMeans
wcss = []
for i in range (1, 10):
    kmeans = KMeans(n_clusters= i, init='k-means++', random_state = 42)
    kmeans.fit(X)
    wcss.append(kmeans.inertia_)
plt.plot(range(1,10), wcss)
plt.title('Elbow Method')
```

```
plt.xlabel('No of clusters')
plt.ylabel('WCSS')
plt.show()
```

```
/usr/local/lib/python3.9/dist-packages/sklearn/cluster/_kmeans.py:870: FutureWarning: Th
  warnings.warn(
/usr/local/lib/python3.9/dist-packages/sklearn/cluster/_kmeans.py:870: FutureWarning: Th
  warnings.warn(
/usr/local/lib/python3.9/dist-packages/sklearn/cluster/_kmeans.py:870: FutureWarning: Th
  warnings.warn(
/usr/local/lib/python3.9/dist-packages/sklearn/cluster/_kmeans.py:870: FutureWarning: Th
  warnings.warn(
/usr/local/lib/python3.9/dist-packages/sklearn/cluster/_kmeans.py:870: FutureWarning: Th
  warnings.warn(
/usr/local/lib/python3.9/dist-packages/sklearn/cluster/_kmeans.py:870: FutureWarning: Th
  warnings.warn(
/usr/local/lib/python3.9/dist-packages/sklearn/cluster/_kmeans.py:870: FutureWarning: Th
  warnings.warn(
/usr/local/lib/python3.9/dist-packages/sklearn/cluster/_kmeans.py:870: FutureWarning: Th
  warnings.warn(
/usr/local/lib/python3.9/dist-packages/sklearn/cluster/_kmeans.py:870: FutureWarning: Th
  warnings.warn(
```




```
#From the elbow method above, the optimal number of clusters to be used is 3
kmeans = KMeans(n_clusters= 2, init='k-means++', random_state = 35)
y_means= kmeans.fit_predict (X)
```

```
/usr/local/lib/python3.9/dist-packages/sklearn/cluster/_kmeans.py:870: FutureWarning: Th
  warnings.warn(
```

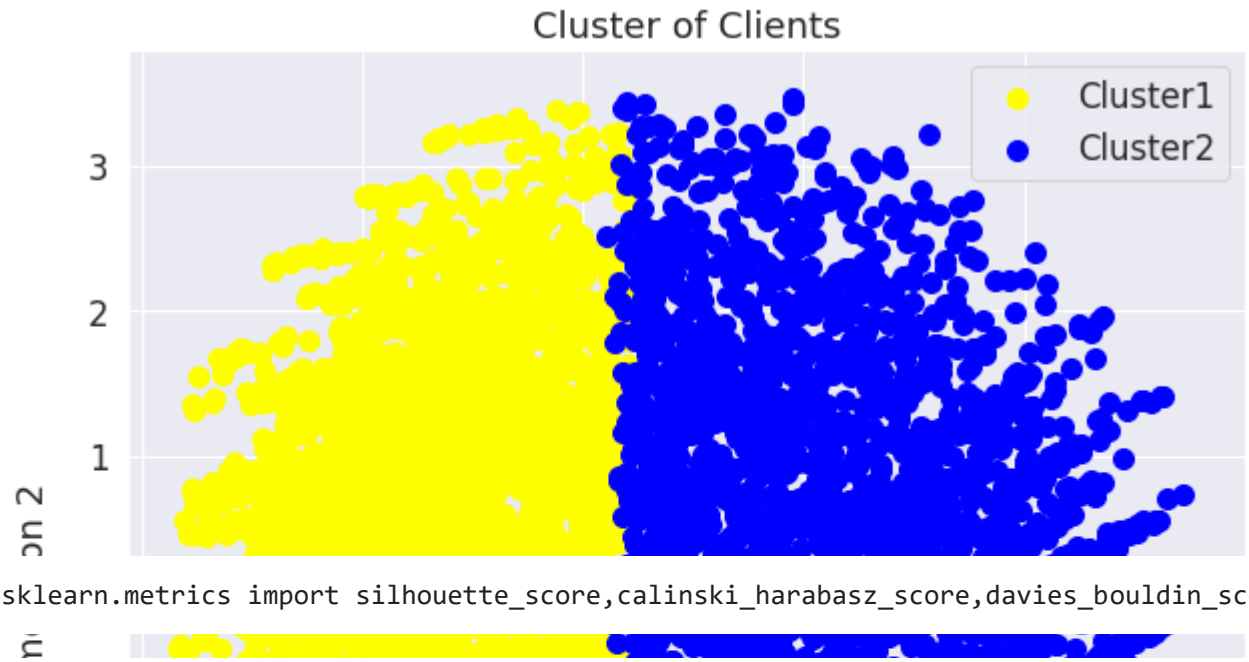
```
y_means
```

```
array([0, 0, 0, ..., 0, 0, 1], dtype=int32)
```

```
# We need to reduce the dimensionality before we can visualize
# The explained ratio tells us how much is compressed into the first few components. We use t
# The cummulative variance should be minimum of 70%. Meaning the decomposed data has minimum
# We don't want all of the information because some of them are noise
from sklearn import decomposition
from sklearn.decomposition import PCA
pca = decomposition.PCA()
X_decomp = pca.fit_transform(X)
pca.explained_variance_ratio_
```

```
     array([0.22249734, 0.1218598 , 0.07875656, 0.06394512, 0.05668375,
            0.05272684, 0.04976897, 0.04542665, 0.04272823, 0.04089064,
            0.03778958, 0.03690806, 0.03606025, 0.02997123, 0.029608  ,
            0.02464656, 0.01659734, 0.01033033, 0.00280475])
```

```
#Visualize the cluster
color_list = ['yellow','blue']
plt.figure(figsize=(10,10))
for i in range(2):
    plt.scatter(X_decomp[y_means== i, 0], X_decomp[y_means== i, 1], s=100, c = color_list[i],
plt.title('Cluster of Clients')
plt.xlabel('Dimension 1')
plt.ylabel('Dimension 2')
plt.legend()
plt.show()
```




```
from sklearn.metrics import silhouette_score,calinski_harabasz_score,davies_bouldin_score
```

```
#Evaluating performance of the model
print(silhouette_score(X, y_means))
print(davies_bouldin_score(X, y_means))
print(calinski_harabasz_score(X, y_means))
```

```
0.15708950881682246
2.2545066295692724
1304.314247395666
```

```
#using number of clusters =3
# Fit KMeans to the dataset
kmeans = KMeans(n_clusters= 3, init='k-means++', random_state = 35)
y_means_2= kmeans.fit_predict (X)
```

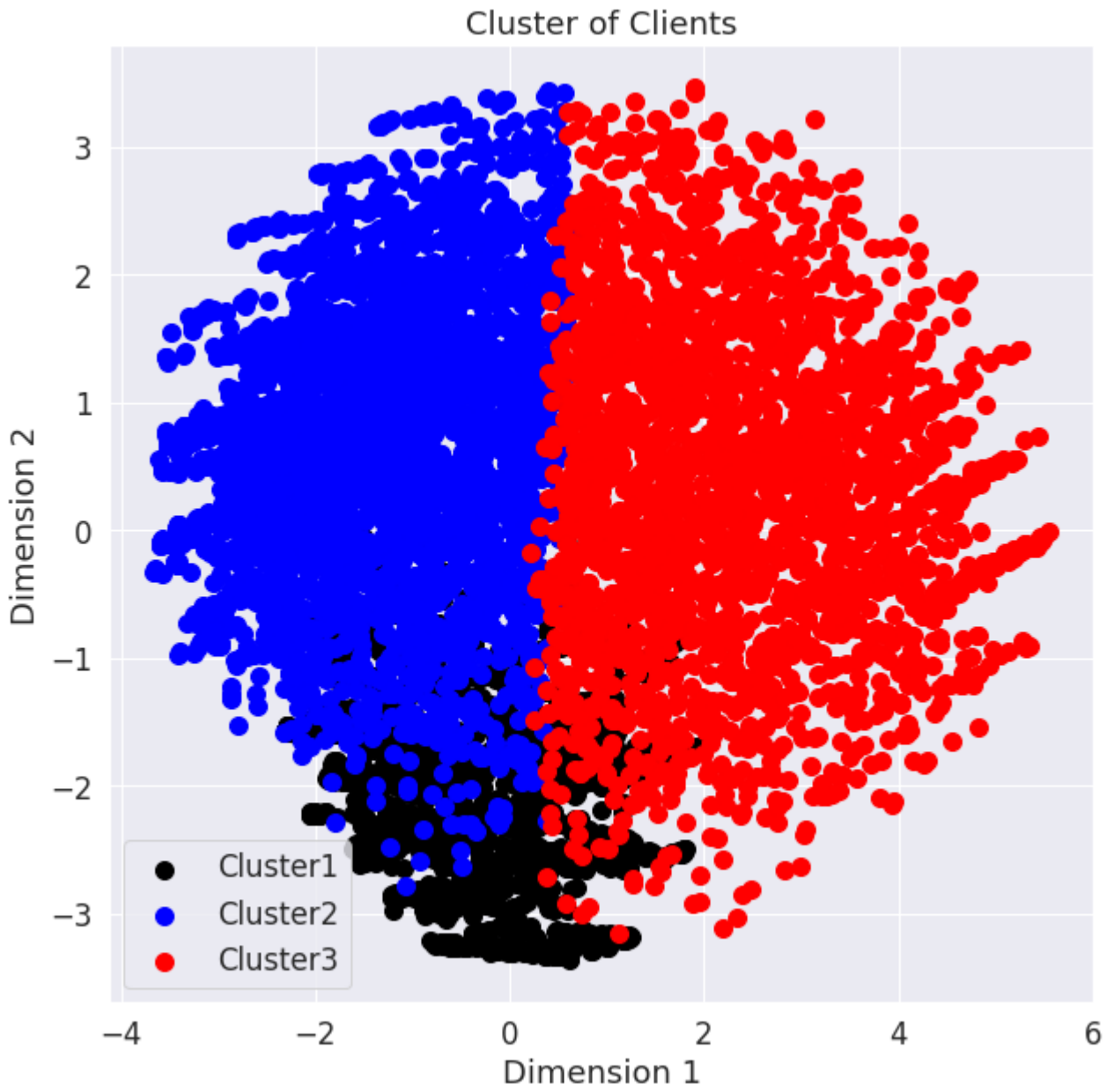
```
/usr/local/lib/python3.9/dist-packages/sklearn/cluster/_kmeans.py:870: FutureWarning: Th
  warnings.warn(
```

```
y_means_2
```

```
array([1, 1, 1, ..., 1, 1, 2], dtype=int32)
```

```
#Visualize the cluster
color_list = ['black','blue','red']
plt.figure(figsize=(10,10))

for i in range(3):
    plt.scatter(X_decomp[y_means_2== i, 0], X_decomp[y_means_2== i, 1], s=100, c = color_list
```

```
plt.title('Cluster of Clients')
plt.xlabel('Dimension 1')
plt.ylabel('Dimension 2')
plt.legend()
plt.show()
```




```
print(silhouette_score(X, y_means_2))
print(davies_bouldin_score(X, y_means_2))
print(calinski_harabasz_score(X, y_means_2))
```

```
0.13811226908613305
2.032347692884629
1120.6313197199052
```

```
#Smaller DB Index is better
#Higher value for Calinski Harabaz index shows better performance
```

```
#The higher the Silhouette Coefficients (the closer to +1), the more is the separation betwee

y_means
```

```
array([0, 0, 0, ..., 0, 0, 1], dtype=int32)
```

```
y =9


clusterDF=pd.DataFrame(y_means,columns=['Clusters'] )

clusterDF.head(10)
```

	Clusters
0	0
1	0
2	0
3	0
4	0
5	0
6	0
7	0
8	1
9	1

```
segmentationDF=pd.concat([data3 ,clusterDF], axis=1)

segmentationDF.head()
```

	customerID	gender	SeniorCitizen	Partner	Dependents	tenure	PhoneService	Multipl
0	5365.0	0.0	0.0	1.0	0.0	1.0	0.0	
1	3953.0	1.0	0.0	0.0	0.0	34.0	1.0	

```
segmentationDF=pd.concat([data3 ,clusterDF], axis=1)
```

4	6500.0	0.0	0.0	0.0	0.0	2.0	1.0	

```
data=data.dropna()
```

```
#Concat the clustering dataframe and original dataframe

segDF=pd.concat([data ,clusterDF], axis=1)

segDF.head()
```

	customerID	gender	SeniorCitizen	Partner	Dependents	tenure	PhoneService	Multipl
0	7590-VHVEG	Female	0.0	Yes	No	1.0	No	No
1	5575-GNVDE	Male	0.0	No	No	34.0	Yes	
2	3668-QPYBK	Male	0.0	No	No	2.0	Yes	
3	7795-CFOCW	Male	0.0	No	No	45.0	No	No
4	9237-HQITU	Female	0.0	No	No	2.0	Yes	

5 rows × 22 columns

```
segDF.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 7043 entries, 0 to 6754
Data columns (total 22 columns):
 #   Column            Non-Null Count  Dtype
---  ------            --------------  -----
 0   customerID        7032 non-null   object
 1   gender            7032 non-null   object
 2   SeniorCitizen     7032 non-null   float64
```

```
 3   Partner           7032 non-null   object
 4   Dependents        7032 non-null   object
 5   tenure            7032 non-null   float64
 6   PhoneService      7032 non-null   object
 7   MultipleLines     7032 non-null   object
 8   InternetService   7032 non-null   object
 9   OnlineSecurity    7032 non-null   object
 10  OnlineBackup      7032 non-null   object
 11  DeviceProtection  7032 non-null   object
 12  TechSupport       7032 non-null   object
 13  StreamingTV       7032 non-null   object
 14  StreamingMovies   7032 non-null   object
 15  Contract          7032 non-null   object
 16  PaperlessBilling  7032 non-null   object
 17  PaymentMethod     7032 non-null   object
 18  MonthlyCharges    7032 non-null   float64
 19  TotalCharges      7032 non-null   float64
 20  Churn             7032 non-null   object
 21  Clusters          7032 non-null   float64
dtypes: float64(5), object(17)
memory usage: 1.2+ MB
```

```
#Extracting those customers that belong to cluster 0
segment_1 = segDF.loc[(segDF['Clusters']==0)]
segment_1.head()
segment_1.shape
```

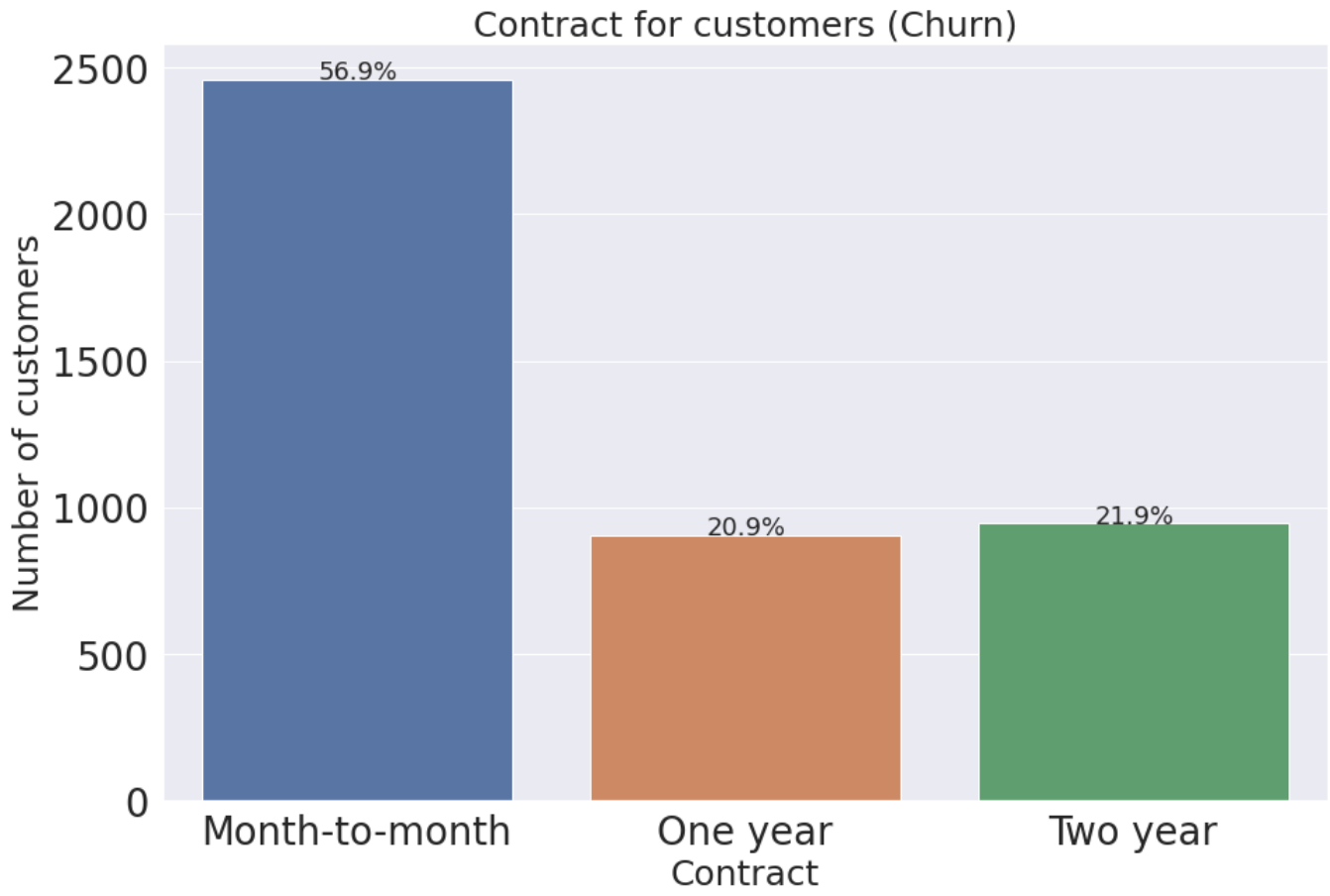
```
(4320, 22)
```

```
#Extracting those customers that belong to cluster 0
segment_2 = segDF.loc[(segDF['Clusters']==1)]
segment_2.head()
segment_2.shape
```

```
(2712, 22)
```

```
plt.figure(figsize=(15,10))
ax=sns.countplot(x='Contract', data=segment_1)
sns.set(font_scale=2.5)
ax.set_title('Contract for customers (Churn)' , fontsize = 25)
plt.xlabel('Contract', fontsize=25)
plt.ylabel('Number of customers', fontsize=25)
plt.xticks(rotation='horizontal')

total = float(len(segment_1))
for p in ax.patches:
    percentage = '{:.1f}%'.format(100 * p.get_height()/total)
    x = p.get_x() + p.get_width() / 2 - 0.1
```

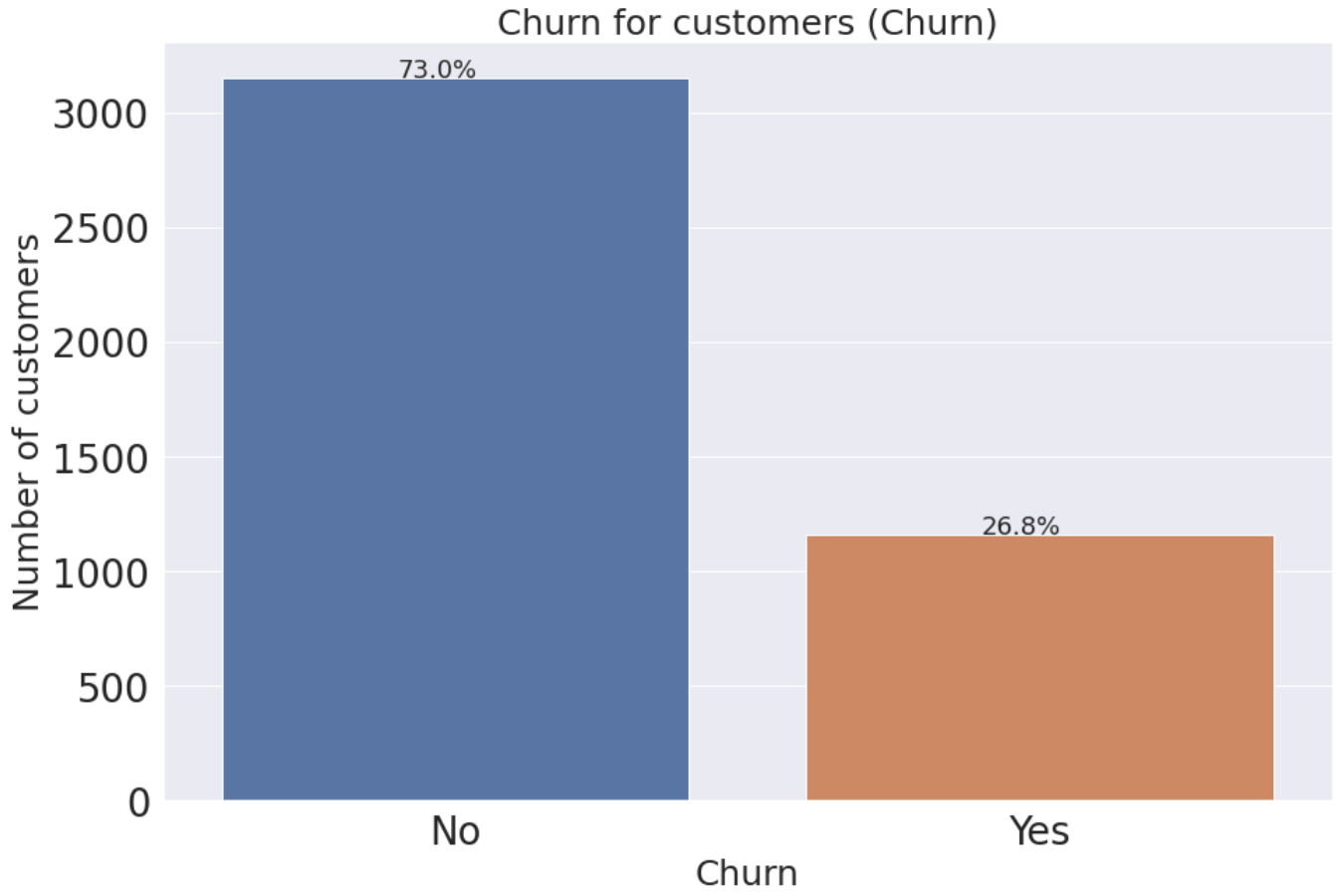
```
    y = p.get_y() + p.get_height()
    ax.annotate(percentage, (x, y), size=18)
```



Double-click (or enter) to edit

```
plt.figure(figsize=(15,10))
ax=sns.countplot(x='Churn', data=segment_1)
sns.set(font_scale=2.5)
ax.set_title('Churn for customers (Churn)' , fontsize = 25)
plt.xlabel('Churn', fontsize=25)
plt.ylabel('Number of customers', fontsize=25)
plt.xticks(rotation='horizontal')

total = float(len(segment_1))
```

```
for p in ax.patches:
    percentage = '{:.1f}%'.format(100 * p.get_height()/total)
    x = p.get_x() + p.get_width() / 2 - 0.1
    y = p.get_y() + p.get_height()
    ax.annotate(percentage, (x, y), size=18)
```




```
segment_1.head()
```

	customerID	gender	SeniorCitizen	Partner	Dependents	tenure	PhoneService	Multipl
0	7590-VHVEG	Female	0.0	Yes	No	1.0	No	No
1	5575-GNVDE	Male	0.0	No	No	34.0	Yes	
2	3668-QPYBK	Male	0.0	No	No	2.0	Yes	
3	7795-CFOCW	Male	0.0	No	No	45.0	No	No

```
segment_1["Churn"].value_counts(normalize=True)
```

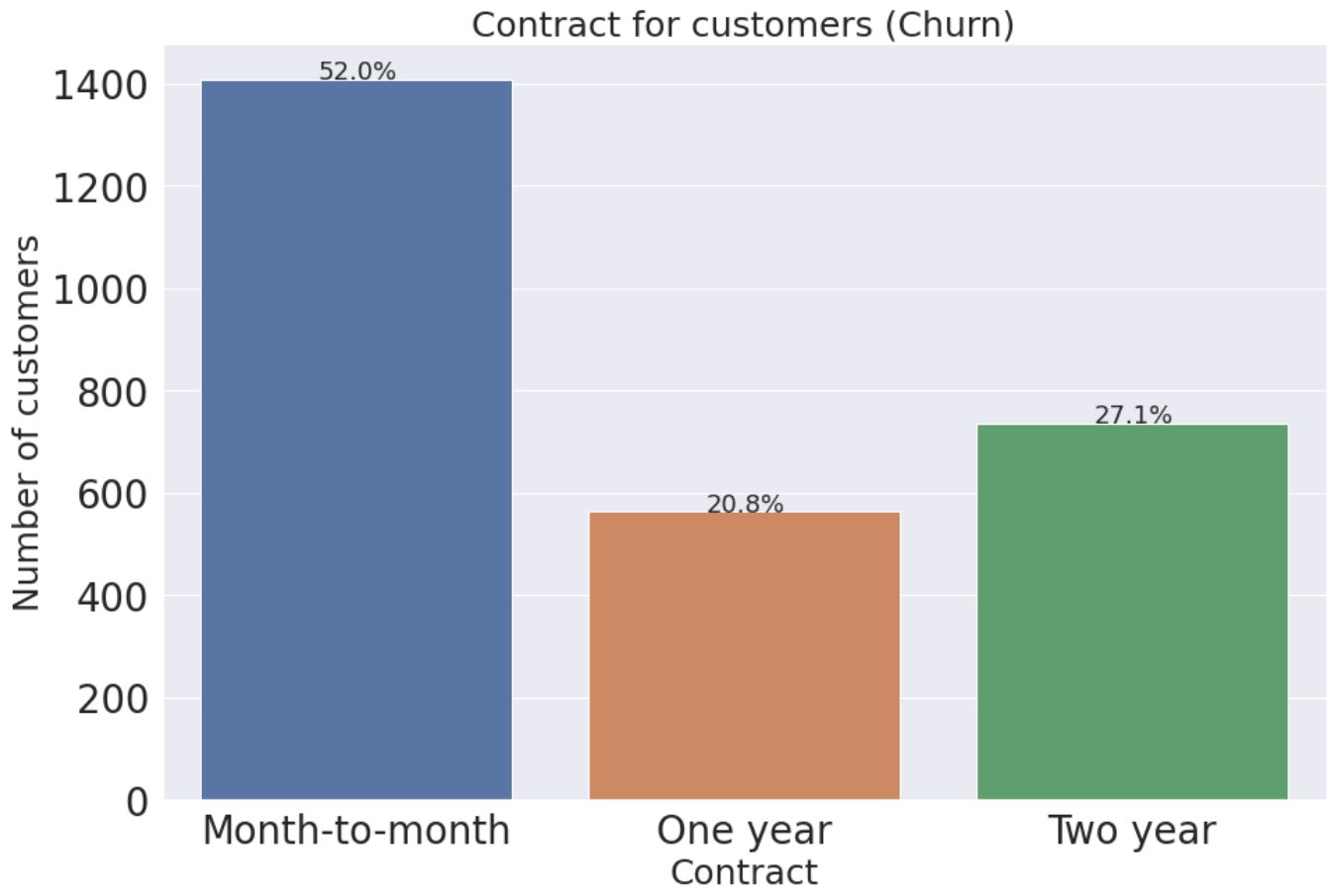
```
No     0.731215
Yes    0.268785
Name: Churn, dtype: float64
```

```
segment_2["Churn"].value_counts(normalize=True)
```

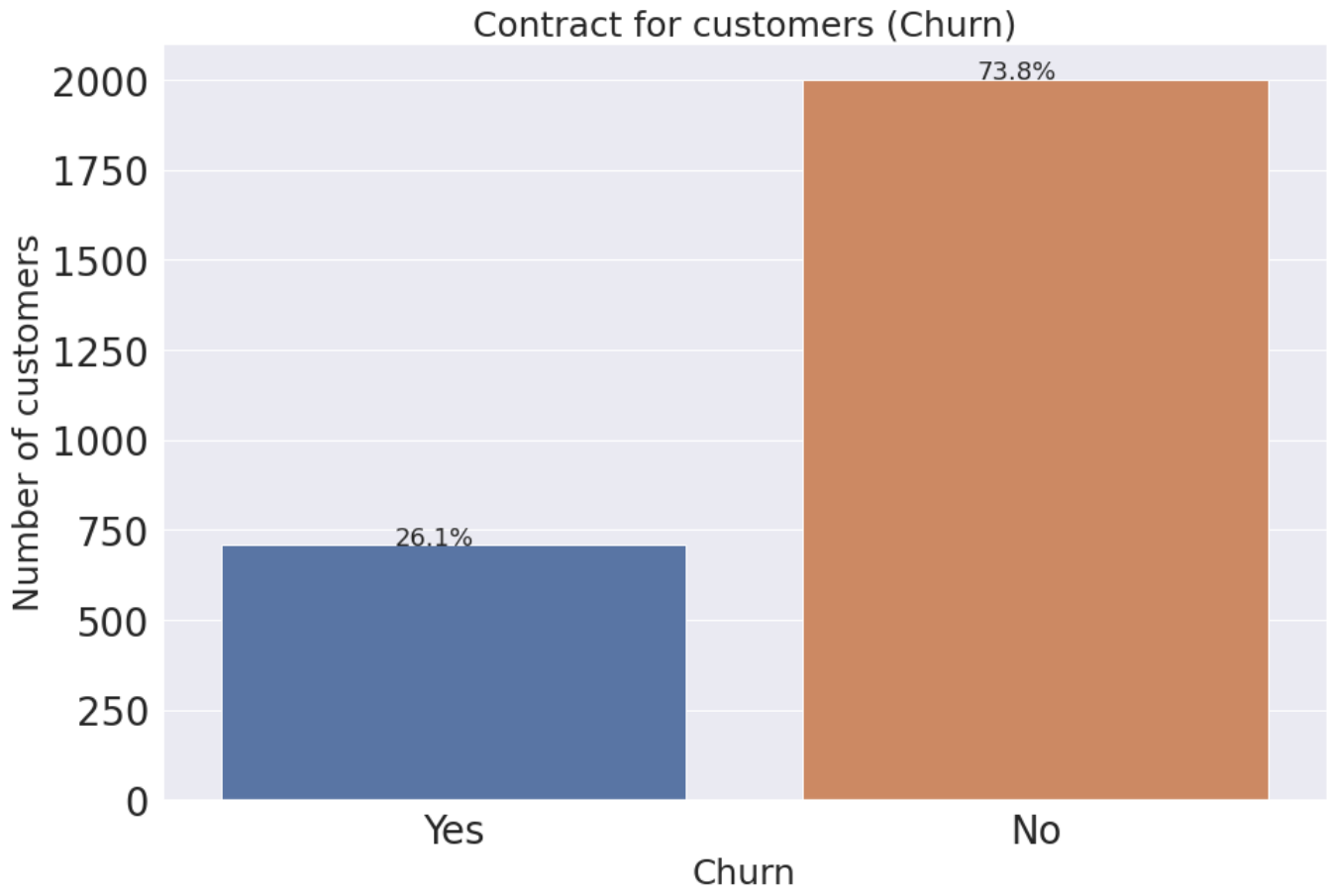
```
No     0.739018
Yes    0.260982
Name: Churn, dtype: float64
```

```
# Segment 2
```

```
plt.figure(figsize=(15,10))
ax=sns.countplot(x='Contract', data=segment_2)
sns.set(font_scale=2.5)
ax.set_title('Contract for customers (Churn)' , fontsize = 25)
plt.xlabel('Contract', fontsize=25)
plt.ylabel('Number of customers', fontsize=25)
plt.xticks(rotation='horizontal')

total = float(len(segment_2))
for p in ax.patches:
    percentage = '{:.1f}%'.format(100 * p.get_height()/total)
    x = p.get_x() + p.get_width() / 2 - 0.1
    y = p.get_y() + p.get_height()
    ax.annotate(percentage, (x, y), size=18)
```




```
plt.figure(figsize=(15,10))
ax=sns.countplot(x='Churn', data=segment_2)
sns.set(font_scale=2.5)
ax.set_title('Contract for customers (Churn)' , fontsize = 25)
plt.xlabel('Churn', fontsize=25)
plt.ylabel('Number of customers', fontsize=25)
plt.xticks(rotation='horizontal')

total = float(len(segment_2))
for p in ax.patches:
    percentage = '{:.1f}%'.format(100 * p.get_height()/total)
    x = p.get_x() + p.get_width() / 2 - 0.1
    y = p.get_y() + p.get_height()
    ax.annotate(percentage, (x, y), size=18)
```




```
segment_2["Churn"].value_counts(normalize=True)
```

```
No     0.739018
Yes    0.260982
Name: Churn, dtype: float64
```

```
segment_1["Churn"].value_counts(normalize=True)
```

```
No     0.731215
Yes    0.268785
Name: Churn, dtype: float64
```

```
# Using the churn data for clustering
```

```
dataKeep = df
```

```
df.shape
```

```
(7043, 21)
```

```
#Churn data
churnDf = df[df["Churn"]=="Yes"]
churnDf.shape
```

```
(1869, 21)
```

```
#Churn data
NochurnDf = df[df["Churn"]=="No"]
NochurnDf.shape
```

```
(5174, 21)
```

```
churnDf["Churn"].value_counts(normalize=True)
```

```
Yes    1.0
Name: Churn, dtype: float64
```

```
churnDf.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 1869 entries, 2 to 7041
Data columns (total 21 columns):
 #   Column            Non-Null Count  Dtype  
---  ------            --------------  -----  
 0   customerID        1869 non-null   object 
 1   gender            1869 non-null   object 
 2   SeniorCitizen     1869 non-null   int64  
 3   Partner           1869 non-null   object 
 4   Dependents        1869 non-null   object 
 5   tenure            1869 non-null   int64  
 6   PhoneService      1869 non-null   object 
 7   MultipleLines     1869 non-null   object 
 8   InternetService   1869 non-null   object 
 9   OnlineSecurity    1869 non-null   object 
 10  OnlineBackup      1869 non-null   object 
 11  DeviceProtection  1869 non-null   object 
 12  TechSupport       1869 non-null   object 
 13  StreamingTV       1869 non-null   object 
 14  StreamingMovies   1869 non-null   object 
 15  Contract          1869 non-null   object 
 16  PaperlessBilling  1869 non-null   object 
 17  PaymentMethod     1869 non-null   object 
 18  MonthlyCharges    1869 non-null   float64
 19  TotalCharges      1869 non-null   float64
 20  Churn             1869 non-null   object 
```

```
dtypes: float64(2), int64(2), object(17)
memory usage: 321.2+ KB
```

```
# Add this later
churnDf.head()
```

	customerID	gender	SeniorCitizen	Partner	Dependents	tenure	PhoneService	Multip
2	3668-QPYBK	Male	0	No	No	2	Yes	
4	9237-HQITU	Female	0	No	No	2	Yes	
5	9305-CDSKC	Female	0	No	No	8	Yes	
8	7892-POOKP	Female	0	Yes	No	28	Yes	
13	0280-XJGEX	Male	0	No	No	49	Yes	

5 rows × 21 columns

```
churnDf2 = churnDf.drop(['customerID','Churn'], axis=1)
churnDf2.head()
```

	gender	SeniorCitizen	Partner	Dependents	tenure	PhoneService	MultipleLines	Int
2	Male	0	No	No	2	Yes	No	
4	Female	0	No	No	2	Yes	No	
5	Female	0	No	No	8	Yes	Yes	
8	Female	0	Yes	No	28	Yes	Yes	
13	Male	0	No	No	49	Yes	Yes	

```
churnDf2.info()
```

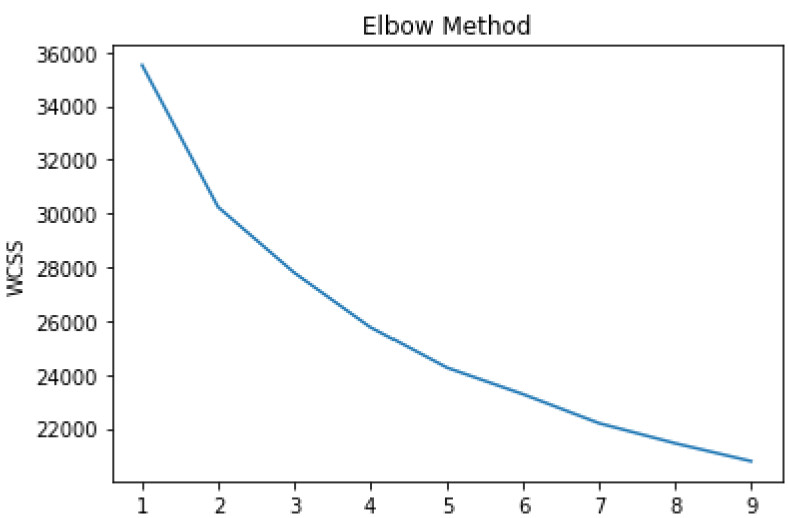
```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 1869 entries, 2 to 7041
Data columns (total 19 columns):
 #   Column            Non-Null Count  Dtype  
---  ------            --------------  -----  
 0   gender            1869 non-null   object 
 1   SeniorCitizen     1869 non-null   int64  
 2   Partner           1869 non-null   object 
 3   Dependents        1869 non-null   object 
 4   tenure            1869 non-null   int64  
 5   PhoneService      1869 non-null   object 
 6   MultipleLines     1869 non-null   object 
 7   InternetService   1869 non-null   object 
 8   OnlineSecurity    1869 non-null   object 
 9   OnlineBackup      1869 non-null   object 
 10  DeviceProtection  1869 non-null   object 
 11  TechSupport       1869 non-null   object 
 12  StreamingTV       1869 non-null   object 
 13  StreamingMovies   1869 non-null   object 
 14  Contract          1869 non-null   object 
 15  PaperlessBilling  1869 non-null   object 
 16  PaymentMethod     1869 non-null   object 
 17  MonthlyCharges    1869 non-null   float64
 18  TotalCharges      1869 non-null   float64
dtypes: float64(2), int64(2), object(15)
memory usage: 292.0+ KB
```

```
#Encoding
# encode categorical variables
le = LabelEncoder()

# loop through each column in the dataframe
for column in churnDf2.columns:
    # check if the column has object datatype (i.e. categorical)
    if churnDf2[column].dtype == 'object':
        # use LabelEncoder to encode the categorical values
        churnDf2[column] = le.fit_transform(churnDf2[column])

# Use this churn data for clustering
x = churnDf2.values


standardizer = StandardScaler()
x = standardizer.fit_transform(x)


from sklearn.cluster import KMeans
wcss = []
for i in range (1, 10):
    kmeans = KMeans(n_clusters= i, init='k-means++', random_state = 42)
```

```
    kmeans.fit(x)
    wcss.append(kmeans.inertia_)
plt.plot(range(1,10), wcss)
plt.title('Elbow Method')
plt.xlabel('No of clusters')
plt.ylabel('WCSS')
plt.show()


#From the elbow method above, the optimal number of clusters to be used is 2
kmeans = KMeans(n_clusters= 2, init='k-means++', random_state = 35)
y_means= kmeans.fit_predict (x)

y_means

from sklearn import decomposition
from sklearn.decomposition import PCA
pca = decomposition.PCA()
X_decomp = pca.fit_transform(x)
pca.explained_variance_ratio_

#Visualize the cluster
color_list = ['red','blue']
plt.figure(figsize=(10,10))
for i in range(2):
    plt.scatter(X_decomp[y_means== i, 0], X_decomp[y_means== i, 1], s=100, c = color_list[i],
plt.title('Cluster of Clients')
plt.xlabel('Dimension 1')
plt.ylabel('Dimension 2')
plt.legend()
plt.show()


# loop through each column in the dataframe
for column in churnDf2.columns:
    # check if the column has object datatype (i.e. categorical)
    if churnDf2[column].dtype == 'object':
        # use LabelEncoder to encode the categorical values
        churnDf2[column] = le.fit_transform(churnDf2[column])


# Use this churn data for clustering
x = churnDf2.values


standardizer = StandardScaler()
x = standardizer.fit_transform(x)



from sklearn.cluster import KMeans
wcss = []
```

```
for i in range (1, 10):
    kmeans = KMeans(n_clusters= i, init='k-means++', random_state = 42)
    kmeans.fit(x)
    wcss.append(kmeans.inertia_)
plt.plot(range(1,10), wcss)
plt.title('Elbow Method')
plt.xlabel('No of clusters')
plt.ylabel('WCSS')
plt.show()
```

```
/usr/local/lib/python3.9/dist-packages/sklearn/cluster/_kmeans.py:870: FutureWarning: Th
  warnings.warn(
/usr/local/lib/python3.9/dist-packages/sklearn/cluster/_kmeans.py:870: FutureWarning: Th
  warnings.warn(
/usr/local/lib/python3.9/dist-packages/sklearn/cluster/_kmeans.py:870: FutureWarning: Th
  warnings.warn(
/usr/local/lib/python3.9/dist-packages/sklearn/cluster/_kmeans.py:870: FutureWarning: Th
  warnings.warn(
/usr/local/lib/python3.9/dist-packages/sklearn/cluster/_kmeans.py:870: FutureWarning: Th
  warnings.warn(
/usr/local/lib/python3.9/dist-packages/sklearn/cluster/_kmeans.py:870: FutureWarning: Th
  warnings.warn(
/usr/local/lib/python3.9/dist-packages/sklearn/cluster/_kmeans.py:870: FutureWarning: Th
  warnings.warn(
/usr/local/lib/python3.9/dist-packages/sklearn/cluster/_kmeans.py:870: FutureWarning: Th
  warnings.warn(
/usr/local/lib/python3.9/dist-packages/sklearn/cluster/_kmeans.py:870: FutureWarning: Th
  warnings.warn(
```




```
#From the elbow method above, the optimal number of clusters to be used is 2
kmeans = KMeans(n_clusters= 2, init='k-means++', random_state = 35)
y_means= kmeans.fit_predict (x)
```

```
y_means

from sklearn import decomposition
from sklearn.decomposition import PCA
pca = decomposition.PCA()
X_decomp = pca.fit_transform(x)
pca.explained_variance_ratio_

#Visualize the cluster
color_list = ['red','blue']
plt.figure(figsize=(10,10))
for i in range(2):
    plt.scatter(X_decomp[y_means== i, 0], X_decomp[y_means== i, 1], s=100, c = color_list[i],
plt.title('Cluster of Clients')
plt.xlabel('Dimension 1')
plt.ylabel('Dimension 2')
plt.legend()
plt.show()
```

```
/usr/local/lib/python3.9/dist-packages/sklearn/cluster/_kmeans.py:870: FutureWarning: Th
  warnings.warn(
```


```
set(y_means)
```

```
{0, 1}
```

```
cluster=pd.DataFrame(y_means,columns=['Clusters'] )
```

```
cluster.shape
```

```
(1869, 1)
```

```
cluster.tail()
```

	Clusters
1864	0
1865	0
1866	0
1867	1
1868	0

```
cluster.head()
```

	Clusters
0	0
1	0
2	0
3	1
4	1

```
cluster.isna().sum()
```

```
Clusters    0
dtype: int64
```

```
churnDf.tail()
```

	customerID	gender	SeniorCitizen	Partner	Dependents	tenure	PhoneService	Mult
7021	1699-HPSBG	Male	0	No	No	12	Yes	
7026	8775-CEBBJ	Female	0	No	No	9	Yes	
7032	6894-LFHLY	Male	1	No	No	1	Yes	
7034	0639-TSIQW	Female	0	No	No	67	Yes	
7041	8361-LTMKD	Male	1	Yes	No	4	Yes	

5 rows × 21 columns

```
churnDf.shape
```

```
(1869, 21)
```

```
# To add both dataframes
result = churnDf.join(cluster)
```

```
clusterdf=cluster
```

```
result.shape
```

```
(1869, 22)
```

```
churnDfA = churnDf
clusterA = cluster
```

```
import pandas as pd
```

```
# use reset_index() to align the indices of df1 and df2
churnDfA = churnDfA.reset_index(drop=True)
clusterA = clusterA.reset_index(drop=True)

# concatenate df2 to df1 using concat()
resultAB = pd.concat([churnDfA, clusterA], axis=1)
```

```
# print the resulting dataframe
print(resultAB)
```

```
      customerID  gender  SeniorCitizen Partner Dependents  tenure  \
0     3668-QPYBK    Male              0      No         No       2
1     9237-HQITU  Female              0      No         No       2
2     9305-CDSKC  Female              0      No         No       8
3     7892-POOKP  Female              0     Yes         No      28
4     0280-XJGEX    Male              0      No         No      49
...          ...     ...            ...     ...        ...     ...
1864  1699-HPSBG    Male              0      No         No      12
1865  8775-CEBBJ  Female              0      No         No       9
1866  6894-LFHLY    Male              1      No         No       1
1867  0639-TSIQW  Female              0      No         No      67
1868  8361-LTMKD    Male              1     Yes         No       4

     PhoneService MultipleLines InternetService OnlineSecurity  ...  \
0             Yes            No             DSL            Yes  ...
1             Yes            No     Fiber optic             No  ...
2             Yes           Yes     Fiber optic             No  ...
3             Yes           Yes     Fiber optic             No  ...
4             Yes           Yes     Fiber optic             No  ...
...           ...           ...             ...            ...  ...
1864          Yes            No             DSL             No  ...
1865          Yes            No             DSL             No  ...
1866          Yes           Yes     Fiber optic             No  ...
1867          Yes           Yes     Fiber optic            Yes  ...
1868          Yes           Yes     Fiber optic             No  ...

     TechSupport StreamingTV StreamingMovies        Contract PaperlessBilling  \
0             No          No              No  Month-to-month              Yes
1             No          No              No  Month-to-month              Yes
2             No         Yes             Yes  Month-to-month              Yes
3            Yes         Yes             Yes  Month-to-month              Yes
4             No         Yes             Yes  Month-to-month              Yes
...          ...         ...             ...             ...              ...
1864         Yes         Yes              No        One year              Yes
1865          No          No              No  Month-to-month              Yes
1866          No          No              No  Month-to-month              Yes
1867          No         Yes              No  Month-to-month              Yes
1868          No          No              No  Month-to-month              Yes

                  PaymentMethod MonthlyCharges TotalCharges  Churn  Clusters
0                  Mailed check          53.85       108.15    Yes         0
1              Electronic check          70.70       151.65    Yes         0
2              Electronic check          99.65       820.50    Yes         0
3              Electronic check         104.80      3046.05    Yes         1
4     Bank transfer (automatic)         103.70      5036.30    Yes         1
...                         ...            ...          ...    ...       ...
1864           Electronic check          59.80       727.80    Yes         0
1865  Bank transfer (automatic)          44.20       403.35    Yes         0
1866           Electronic check          75.75        75.75    Yes         0
1867    Credit card (automatic)         102.95      6886.25    Yes         1
1868               Mailed check          74.40       306.60    Yes         0
```

```
[1869 rows x 22 columns]
```

```
resultAB.head()
```

	customerID	gender	SeniorCitizen	Partner	Dependents	tenure	PhoneService	Multipl
0	3668-QPYBK	Male	0	No	No	2	Yes	
1	9237-HQITU	Female	0	No	No	2	Yes	
2	9305-CDSKC	Female	0	No	No	8	Yes	
3	7892-POOKP	Female	0	Yes	No	28	Yes	
4	0280-XJGEX	Male	0	No	No	49	Yes	

5 rows × 22 columns

```
resultAB["Clusters"].value_counts(normalize= True)
```

```
0    0.695024
1    0.304976
Name: Clusters, dtype: float64
```

```
FirstSegment = resultAB[resultAB["Clusters"]==0]
FirstSegment.head()
FirstSegment.shape
```

```
(1299, 22)
```

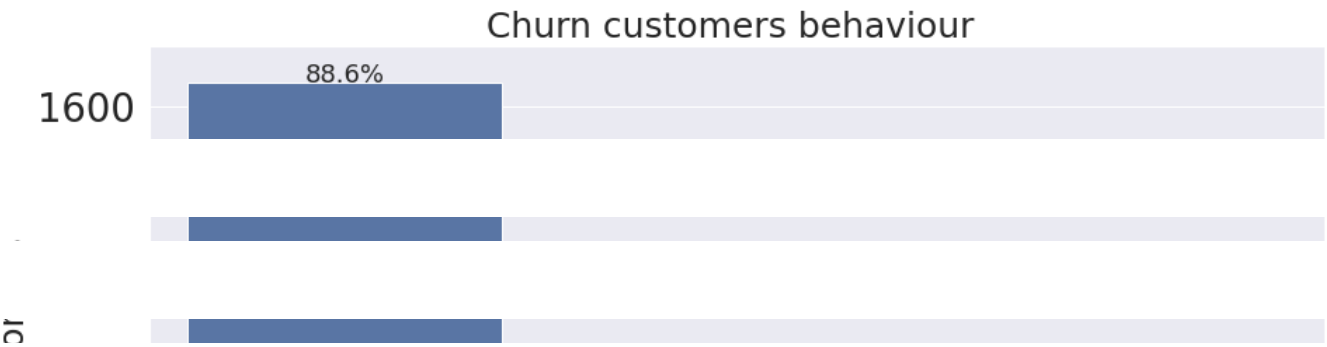
```
SecondSegment =  resultAB[resultAB["Clusters"]==1]
```

```
SecondSegment.head()
SecondSegment.shape
```

```
(570, 22)
```

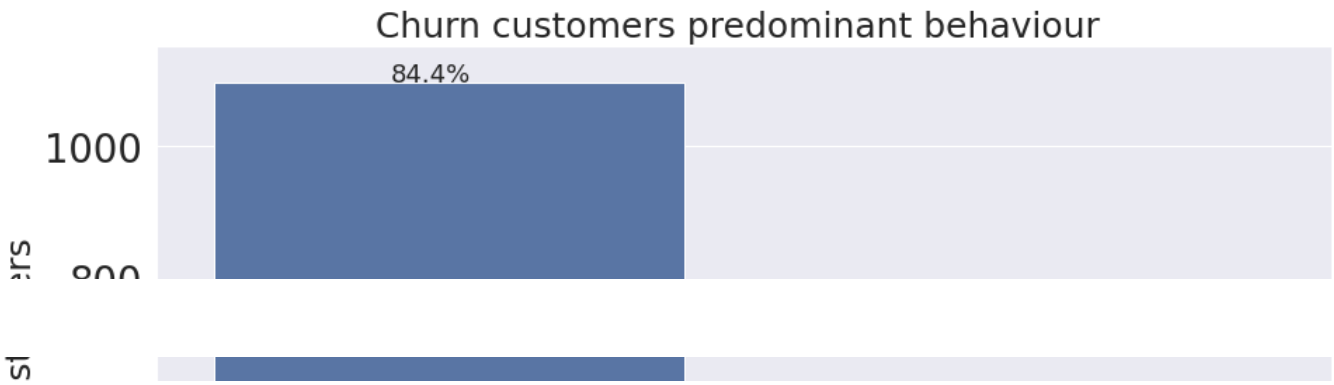
```
# FirstSegment pattern is most important


plt.figure(figsize=(15,10))
ax=sns.countplot(x='Contract', data=FirstSegment)
sns.set(font_scale=2.5)
ax.set_title('Churn customers predominant behaviour ' , fontsize = 25)
plt.xlabel('Contract', fontsize=25)
plt.ylabel('Number of customers', fontsize=25)
plt.xticks(rotation='horizontal')

total = float(len(FirstSegment))
for p in ax.patches:
    percentage = '{:.1f}%'.format(100 * p.get_height()/total)
    x = p.get_x() + p.get_width() / 2 - 0.1
    y = p.get_y() + p.get_height()
    ax.annotate(percentage, (x, y), size=18)
```


```
plt.figure(figsize=(15,10))
ax=sns.countplot(x='Contract', data=resultAB)
sns.set(font_scale=2.5)
ax.set_title('Churn customers behaviour ' , fontsize = 25)
plt.xlabel('Contract', fontsize=25)
plt.ylabel('Number of customers', fontsize=25)
plt.xticks(rotation='horizontal')

total = float(len(resultAB))
for p in ax.patches:
    percentage = '{:.1f}%'.format(100 * p.get_height()/total)
    x = p.get_x() + p.get_width() / 2 - 0.1
    y = p.get_y() + p.get_height()
    ax.annotate(percentage, (x, y), size=18)
```

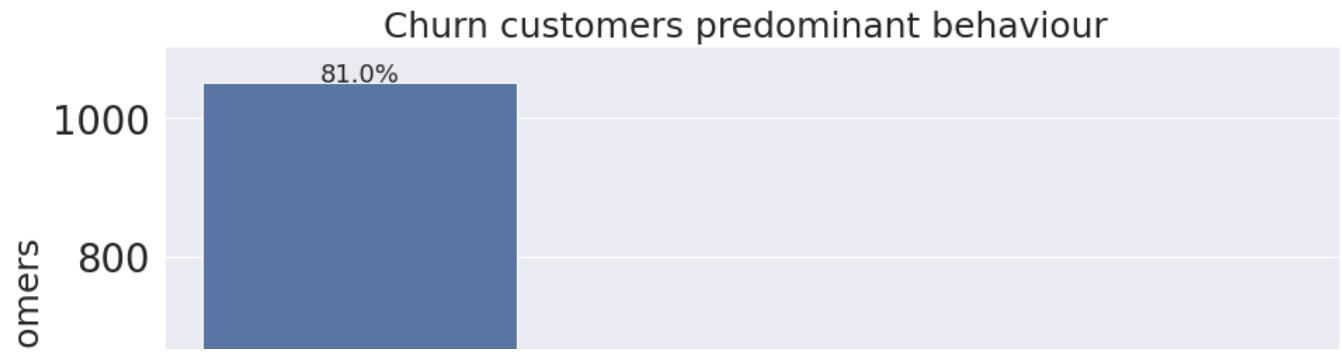



```
plt.figure(figsize=(15,10))
ax=sns.countplot(x='SeniorCitizen', data=FirstSegment)
sns.set(font_scale=2.5)
ax.set_title('Churn customers predominant behaviour ' , fontsize = 25)
plt.xlabel('Senior Citizen', fontsize=25)
plt.ylabel('Number of customers', fontsize=25)
plt.xticks(rotation='horizontal')

total = float(len(FirstSegment))
for p in ax.patches:
    percentage = '{:.1f}%'.format(100 * p.get_height()/total)
    x = p.get_x() + p.get_width() / 2 - 0.1
    y = p.get_y() + p.get_height()
    ax.annotate(percentage, (x, y), size=18)
```

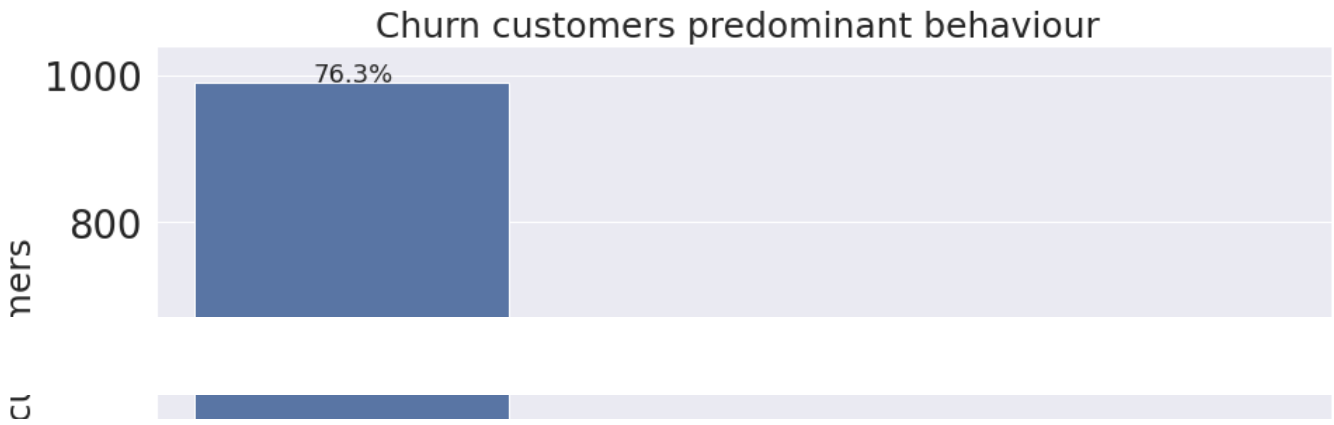

```
plt.figure(figsize=(15,10))
ax=sns.countplot(x='Dependents', data=FirstSegment)
sns.set(font_scale=2.5)
ax.set_title('Churn customers predominant behaviour ' , fontsize = 25)
plt.xlabel('Dependents', fontsize=25)
plt.ylabel('Number of customers', fontsize=25)
plt.xticks(rotation='horizontal')

total = float(len(FirstSegment))
for p in ax.patches:
    percentage = '{:.1f}%'.format(100 * p.get_height()/total)
    x = p.get_x() + p.get_width() / 2 - 0.1
    y = p.get_y() + p.get_height()
    ax.annotate(percentage, (x, y), size=18)
```




```
plt.figure(figsize=(15,10))
ax=sns.countplot(x='TechSupport', data=FirstSegment)
sns.set(font_scale=2.5)
ax.set_title('Churn customers predominant behaviour ' , fontsize = 25)
plt.xlabel('Tech Support', fontsize=25)
plt.ylabel('Number of customers', fontsize=25)
plt.xticks(rotation='horizontal')

total = float(len(FirstSegment))
for p in ax.patches:
    percentage = '{:.1f}%'.format(100 * p.get_height()/total)
    x = p.get_x() + p.get_width() / 2 - 0.1
    y = p.get_y() + p.get_height()
    ax.annotate(percentage, (x, y), size=18)
```




```
plt.figure(figsize=(15,10))
ax=sns.countplot(x='DeviceProtection', data=FirstSegment)
sns.set(font_scale=2.5)
ax.set_title('Churn customers predominant behaviour ' , fontsize = 25)
plt.xlabel('Device Protection', fontsize=25)
plt.ylabel('Number of customers', fontsize=25)
plt.xticks(rotation='horizontal')

total = float(len(FirstSegment))
for p in ax.patches:
    percentage = '{:.1f}%'.format(100 * p.get_height()/total)
    x = p.get_x() + p.get_width() / 2 - 0.1
    y = p.get_y() + p.get_height()
    ax.annotate(percentage, (x, y), size=18)
```




```
#Segmentation for non-churn customer
#Churn data

dataKeep
```

```
no_churn = df[df["Churn"]=="No"]
no_churn.shape
```

```
(5174, 21)
```

No Yes No internet service

```
NochurnDf.head()
```

	customerID	gender	SeniorCitizen	Partner	Dependents	tenure	PhoneService	Multipl
0	7590-VHVEG	Female	0	Yes	No	1	No	No
1	5575-GNVDE	Male	0	No	No	34	Yes	
3	7795-CFOCW	Male	0	No	No	45	No	No
6	1452-KIOVK	Male	0	No	Yes	22	Yes	
7	6713-OKOMC	Female	0	No	No	10	No	No

5 rows × 21 columns

```
no_churn.isna().sum()
```

```
customerID          0
gender              0
SeniorCitizen       0
```

```
Partner             0
Dependents          0
tenure              0
PhoneService        0
MultipleLines       0
InternetService     0
OnlineSecurity      0
OnlineBackup        0
DeviceProtection    0
TechSupport         0
StreamingTV         0
StreamingMovies     0
Contract            0
PaperlessBilling    0
PaymentMethod       0
MonthlyCharges      0
TotalCharges       11
Churn               0
dtype: int64
```

```
dropDF = no_churn
dropDF.shape
```

```
(5163, 21)
```

```
dropDF.dropna(axis=0, inplace=True)
```

```
<ipython-input-123-8dca1ff64b7d>:1: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame

See the caveats in the documentation: https://pandas.pydata.org/pandas-docs/stable/user_
  dropDF.dropna(axis=0, inplace=True)
```

```
no_churn.isna().sum()
```

```
customerID          0
gender              0
SeniorCitizen       0
Partner             0
Dependents          0
tenure              0
PhoneService        0
MultipleLines       0
InternetService     0
OnlineSecurity      0
OnlineBackup        0
DeviceProtection    0
TechSupport         0
StreamingTV         0
StreamingMovies     0
```

```
Contract            0
PaperlessBilling    0
PaymentMethod       0
MonthlyCharges      0
TotalCharges        0
Churn               0
dtype: int64
```

```
no_churn.head()
```

	customerID	gender	SeniorCitizen	Partner	Dependents	tenure	PhoneService	Multipl
0	7590-VHVEG	Female	0	Yes	No	1	No	No
1	5575-GNVDE	Male	0	No	No	34	Yes	
3	7795-CFOCW	Male	0	No	No	45	No	No
6	1452-KIOVK	Male	0	No	Yes	22	Yes	
7	6713-OKOMC	Female	0	No	No	10	No	No

5 rows × 21 columns

```
Keep_no_churn = no_churn
```

```
#df.drop(['A', 'B'], axis=1, inplace=True)
```

```
Keep_no_churn.head()
```

	gender	SeniorCitizen	Partner	Dependents	tenure	PhoneService	MultipleLines	Inte
0	Female	0	Yes	No	1	No	No phone service	
1	Male	0	No	No	34	Yes	No	

```
Keep_no_churn.shape
```

```
(5163, 19)
```

6	Male	0	No	Yes	22	Yes	Yes

```
#Encoding
# encode categorical variables
le = LabelEncoder()

# loop through each column in the dataframe
for column in Keep_no_churn.columns:
    # check if the column has object datatype (i.e. categorical)
    if Keep_no_churn[column].dtype == 'object':
        # use LabelEncoder to encode the categorical values
        Keep_no_churn[column] = le.fit_transform(Keep_no_churn[column])
```

```
<ipython-input-132-7e9bbad642e1>:6: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-docs/stable/u
  Keep_no_churn[column] = le.fit_transform(Keep_no_churn[column])
<ipython-input-132-7e9bbad642e1>:6: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-docs/stable/u
  Keep_no_churn[column] = le.fit_transform(Keep_no_churn[column])
<ipython-input-132-7e9bbad642e1>:6: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-docs/stable/u
  Keep_no_churn[column] = le.fit_transform(Keep_no_churn[column])
<ipython-input-132-7e9bbad642e1>:6: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-docs/stable/u
  Keep_no_churn[column] = le.fit_transform(Keep_no_churn[column])
<ipython-input-132-7e9bbad642e1>:6: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-docs/stable/u
  Keep_no_churn[column] = le.fit_transform(Keep_no_churn[column])
<ipython-input-132-7e9bbad642e1>:6: SettingWithCopyWarning:
```

```
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-docs/stable/u
  Keep_no_churn[column] = le.fit_transform(Keep_no_churn[column])
<ipython-input-132-7e9bbad642e1>:6: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-docs/stable/u
  Keep_no_churn[column] = le.fit_transform(Keep_no_churn[column])
<ipython-input-132-7e9bbad642e1>:6: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-docs/stable/u
  Keep_no_churn[column] = le.fit_transform(Keep_no_churn[column])
<ipython-input-132-7e9bbad642e1>:6: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-docs/stable/u
  Keep_no_churn[column] = le.fit_transform(Keep_no_churn[column])
<ipython-input-132-7e9bbad642e1>:6: SettingWithCopyWarning:
```

```
Keep_no_churn.head()
```

	gender	SeniorCitizen	Partner	Dependents	tenure	PhoneService	MultipleLines	Inte
0	0	0	1	0	1	0	1	
1	1	0	0	0	34	1	0	
3	1	0	0	0	45	0	1	
6	1	0	0	1	22	1	2	
7	0	0	0	0	10	0	1	

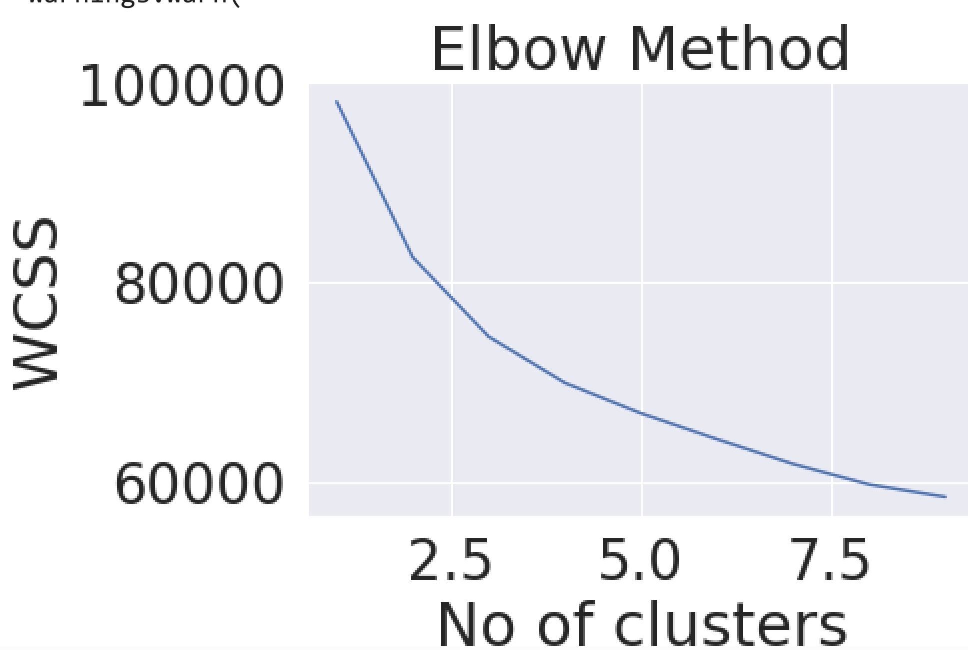
```
X = Keep_no_churn.values
```

```
standardizer = StandardScaler()
X= standardizer.fit_transform(X)
```

```
from sklearn.cluster import KMeans
wcss = []
for i in range (1, 10):
    kmeans = KMeans(n_clusters= i, init='k-means++', random_state = 42)
```

```
    kmeans.fit(X)
    wcss.append(kmeans.inertia_)
plt.plot(range(1,10), wcss)
plt.title('Elbow Method')
plt.xlabel('No of clusters')
plt.ylabel('WCSS')
plt.show()
```

```
/usr/local/lib/python3.9/dist-packages/sklearn/cluster/_kmeans.py:870: FutureWarning: Th
  warnings.warn(
/usr/local/lib/python3.9/dist-packages/sklearn/cluster/_kmeans.py:870: FutureWarning: Th
  warnings.warn(
/usr/local/lib/python3.9/dist-packages/sklearn/cluster/_kmeans.py:870: FutureWarning: Th
  warnings.warn(
/usr/local/lib/python3.9/dist-packages/sklearn/cluster/_kmeans.py:870: FutureWarning: Th
  warnings.warn(
/usr/local/lib/python3.9/dist-packages/sklearn/cluster/_kmeans.py:870: FutureWarning: Th
  warnings.warn(
/usr/local/lib/python3.9/dist-packages/sklearn/cluster/_kmeans.py:870: FutureWarning: Th
  warnings.warn(
/usr/local/lib/python3.9/dist-packages/sklearn/cluster/_kmeans.py:870: FutureWarning: Th
  warnings.warn(
/usr/local/lib/python3.9/dist-packages/sklearn/cluster/_kmeans.py:870: FutureWarning: Th
  warnings.warn(
/usr/local/lib/python3.9/dist-packages/sklearn/cluster/_kmeans.py:870: FutureWarning: Th
  warnings.warn(
```



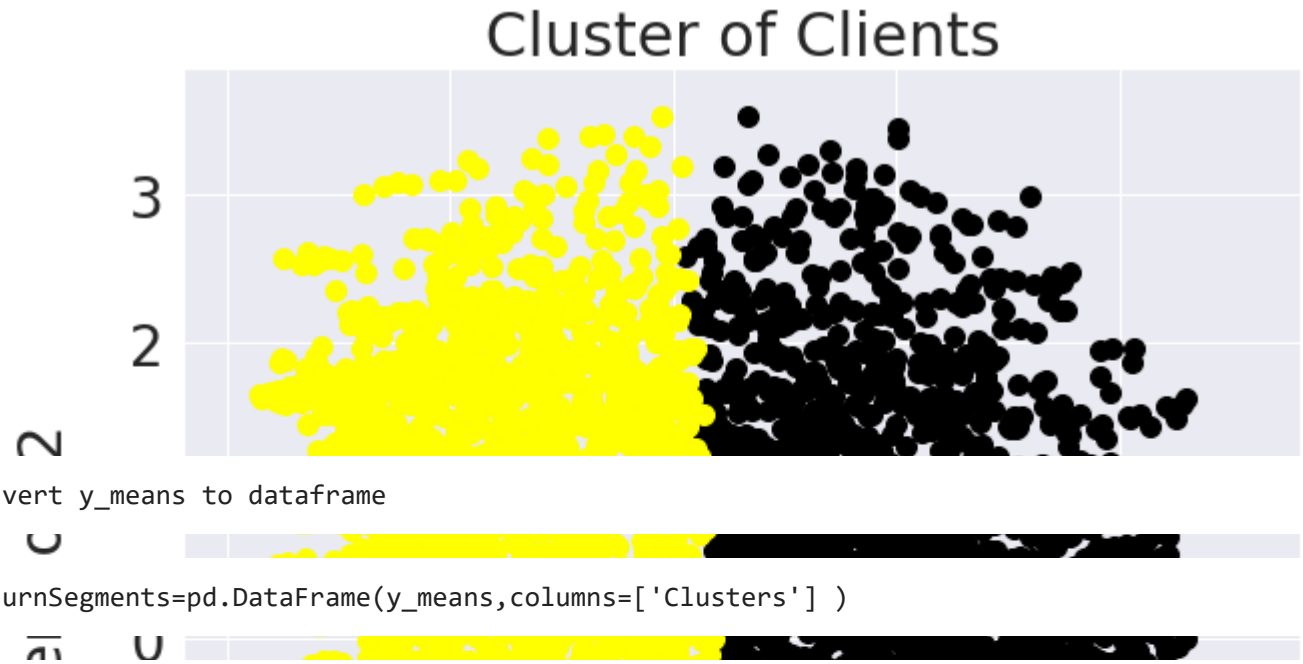

```
#From the elbow method above, the optimal number of clusters to be used is 2
kmeans = KMeans(n_clusters= 2, init='k-means++', random_state = 35)
y_means= kmeans.fit_predict (X)

y_means
```

```
/usr/local/lib/python3.9/dist-packages/sklearn/cluster/_kmeans.py:870: FutureWarning: Th
  warnings.warn(
array([1, 1, 1, ..., 0, 1, 0], dtype=int32)
```

```
from sklearn import decomposition
from sklearn.decomposition import PCA
pca = decomposition.PCA()
X_decomp = pca.fit_transform(X)
pca.explained_variance_ratio_
```

```
array([0.22248186, 0.11218536, 0.07821713, 0.06556404, 0.05696952,
       0.0526986 , 0.05092526, 0.0461607 , 0.04405573, 0.04200296,
       0.03875627, 0.03854388, 0.03685199, 0.03065698, 0.02972419,
       0.02441702, 0.01704661, 0.0101681 , 0.0025738 ])
```

```
#Visualize the cluster
color_list = ['black','yellow']
plt.figure(figsize=(10,10))
for i in range(2):
    plt.scatter(X_decomp[y_means== i, 0], X_decomp[y_means== i, 1], s=100, c = color_list[i],
plt.title('Cluster of Clients')
plt.xlabel('Dimension 1')
plt.ylabel('Dimension 2')
plt.legend()
plt.show()
```




```
# Convert y_means to dataframe

NotChurnSegments=pd.DataFrame(y_means,columns=['Clusters'] )

NotChurnSegments.head()
```

	Clusters
0	1
1	1
2	1
3	1
4	1

```
NotChurnSegments["Clusters"].value_counts(normalize=True)

     1    0.616502
     0    0.383498
     Name: Clusters, dtype: float64


# Get the nor churn data to use


NotChurnSegments.shape

     (5163, 1)




df.shape

     (7043, 21)
```

```
unChurned = df[df["Churn"]=="No"]
```

```
unChurned
```

	customerID	gender	SeniorCitizen	Partner	Dependents	tenure	PhoneService	Mult
0	7590-VHVEG	Female	0	Yes	No	1	No	
1	5575-GNVDE	Male	0	No	No	34	Yes	
3	7795-CFOCW	Male	0	No	No	45	No	
6	1452-KIOVK	Male	0	No	Yes	22	Yes	
7	6713-OKOMC	Female	0	No	No	10	No	
...	...	...	...	...	...	...	...	
7037	2569-WGERO	Female	0	No	No	72	Yes	
7038	6840-RESVB	Male	0	Yes	Yes	24	Yes	
7039	2234-XADUH	Female	0	Yes	Yes	72	Yes	
7040	4801-JZAZL	Female	0	Yes	Yes	11	No	
7042	3186-AJIEK	Male	0	No	No	66	Yes	

5174 rows × 21 columns

```
# Removinf missing values
```

```
unChurned2 = unChurned
```

```
unChurned2.isna().sum()
```

```
customerID          0
gender              0
```

```
SeniorCitizen        0
Partner              0
Dependents           0
tenure               0
PhoneService         0
MultipleLines        0
InternetService      0
OnlineSecurity       0
OnlineBackup         0
DeviceProtection     0
TechSupport          0
StreamingTV          0
StreamingMovies      0
Contract             0
PaperlessBilling     0
PaymentMethod        0
MonthlyCharges       0
TotalCharges        11
Churn                0
dtype: int64
```

```
unChurned2 = unChurned2.dropna()
```

```
unChurned2.shape
```

```
(5163, 21)
```

```
# To add both dataframes
import pandas as pd

# use reset_index() to align the indices of df1 and df2
unChurned2 = unChurned2.reset_index(drop=True)
NotChurnSegments = NotChurnSegments.reset_index(drop=True)

# concatenate df2 to df1 using concat()
NotChurnSegmentsDF = pd.concat([unChurned2, NotChurnSegments], axis=1)
```

```
NotChurnSegmentsDF.head()
```

	customerID	gender	SeniorCitizen	Partner	Dependents	tenure	PhoneService	Multipl
0	7590-VHVEG	Female	0	Yes	No	1	No	No
1	5575-GNVDE	Male	0	No	No	34	Yes	
2	7795-CFOCW	Male	0	No	No	45	No	No
	1452-							

```
NotChurnSegmentsDF.shape
```

```
(5163, 22)
```

```
NotChurnSegmentsDF["Clusters"].value_counts(normalize=True)
```

```
1    0.616502
0    0.383498
Name: Clusters, dtype: float64
```

```
NotChurnSegmentsDF["Clusters"].value_counts()
```

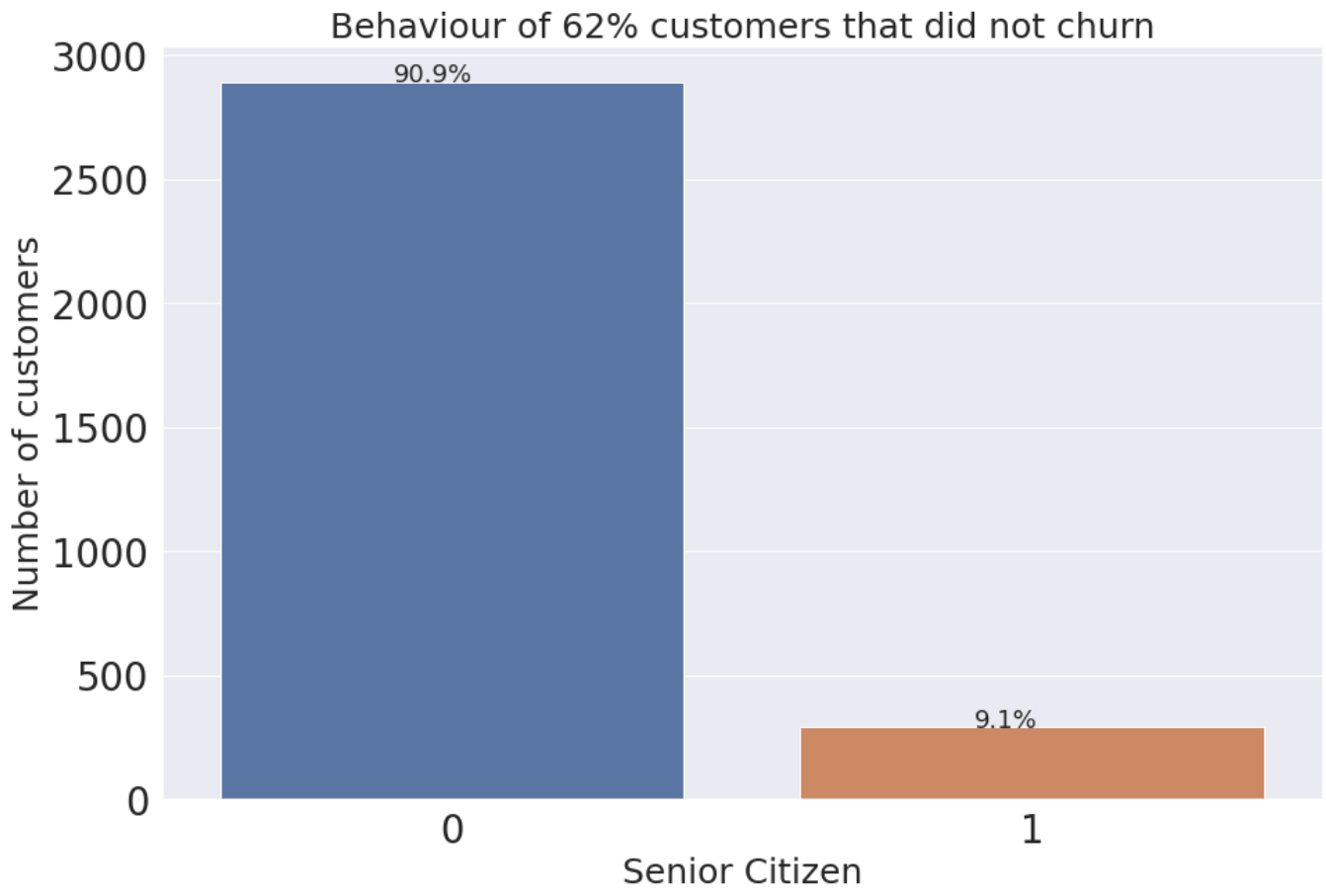
```
1    3183
0    1980
Name: Clusters, dtype: int64
```

```
# Cluster 1 is more important

NotChurnFirstSeg = NotChurnSegmentsDF[NotChurnSegmentsDF["Clusters"]==1]
NotChurnFirstSeg.head()
NotChurnFirstSeg.shape
```

```
(3183, 22)
```

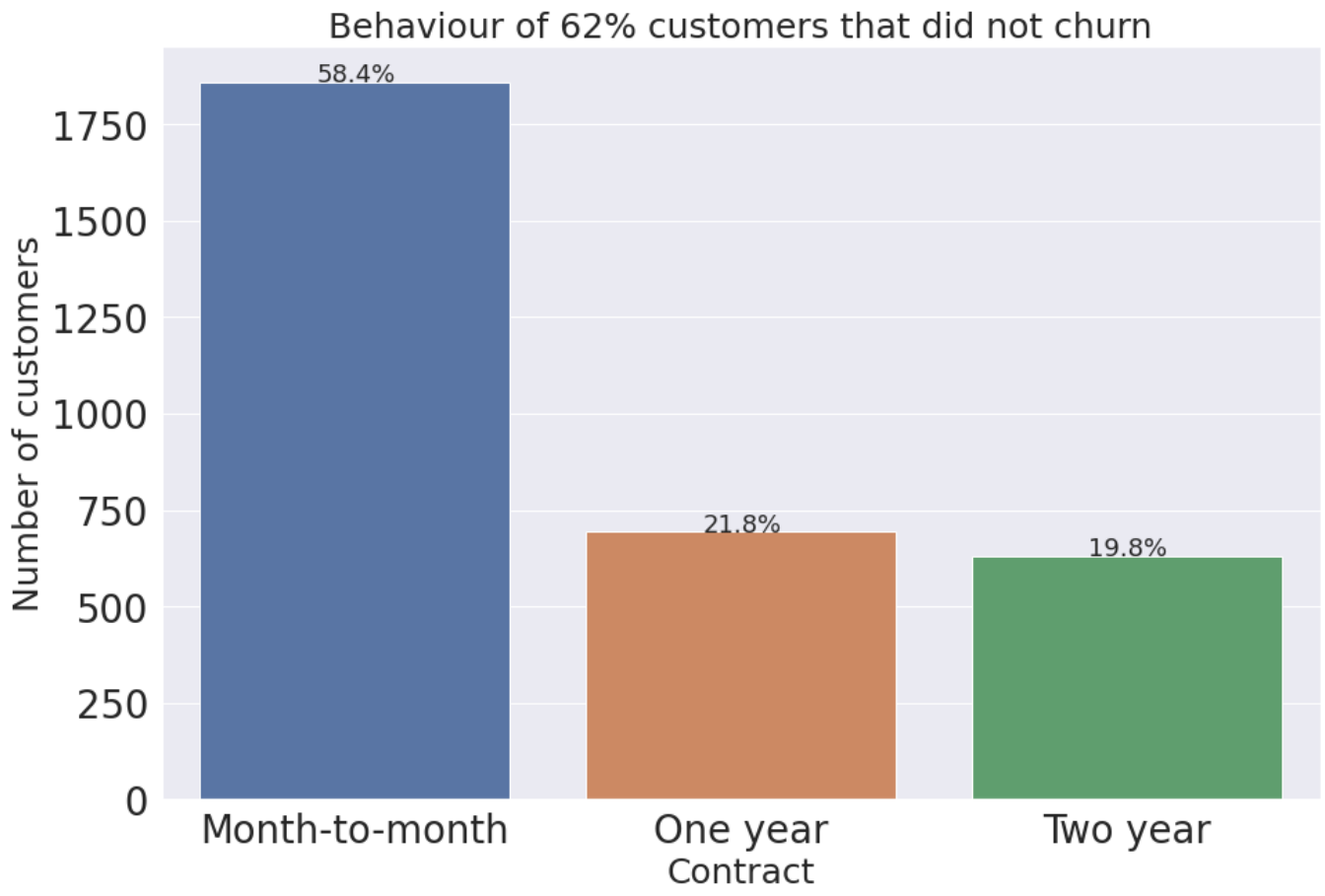
```
# Show behaviour of 62% customers that did not churn
plt.figure(figsize=(15,10))
ax=sns.countplot(x='SeniorCitizen', data=NotChurnFirstSeg)
sns.set(font_scale=2.5)
ax.set_title('Behaviour of 62% customers that did not churn' , fontsize = 25)
plt.xlabel('Senior Citizen', fontsize=25)
plt.ylabel('Number of customers', fontsize=25)
plt.xticks(rotation='horizontal')

total = float(len(NotChurnFirstSeg))
for p in ax.patches:
    percentage = '{:.1f}%'.format(100 * p.get_height()/total)
    x = p.get_x() + p.get_width() / 2 - 0.1
```

```
    y = p.get_y() + p.get_height()
    ax.annotate(percentage, (x, y), size=18)
```



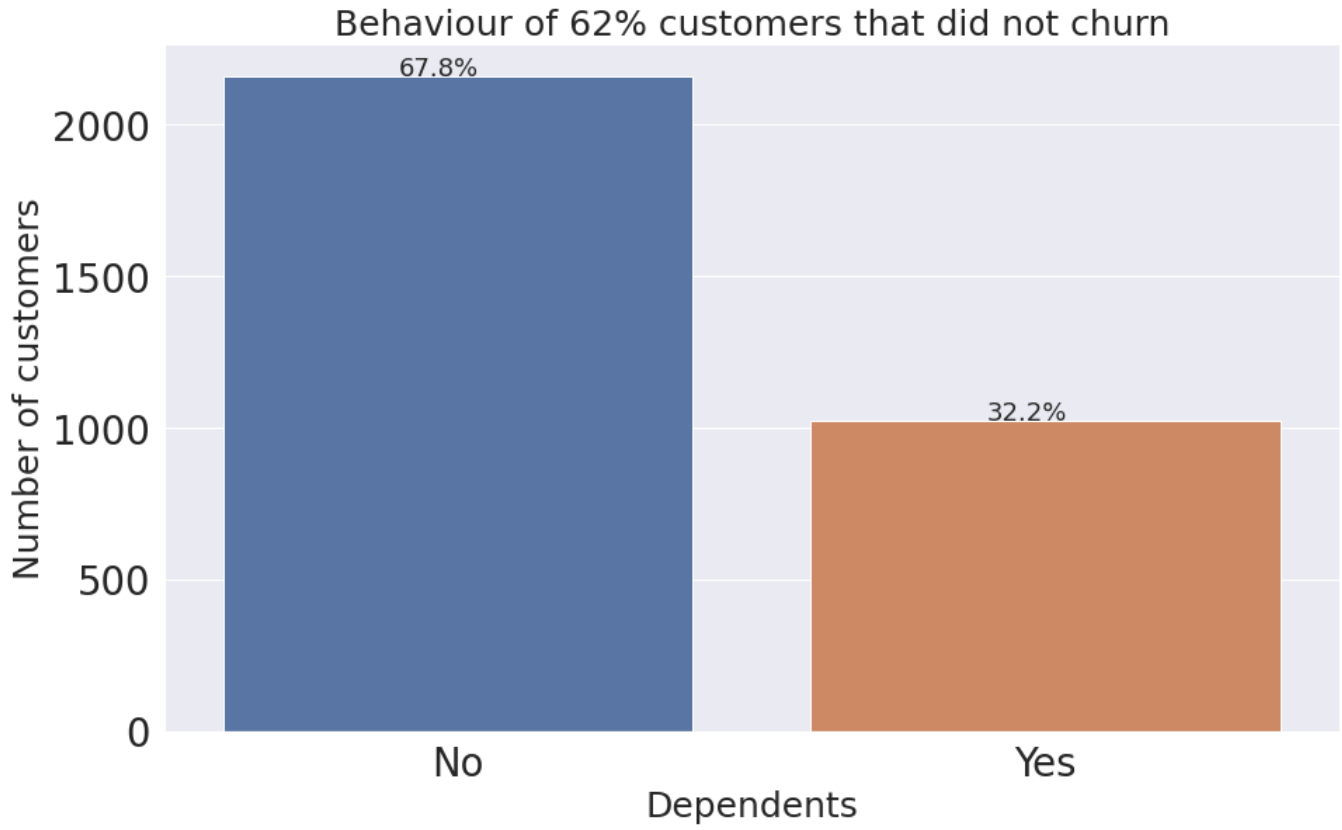

```
# Show behaviour of 62% customers that did not churn
plt.figure(figsize=(15,10))
ax=sns.countplot(x='Contract', data=NotChurnFirstSeg)
sns.set(font_scale=2.5)
ax.set_title('Behaviour of 62% customers that did not churn' , fontsize = 25)
plt.xlabel('Contract', fontsize=25)
plt.ylabel('Number of customers', fontsize=25)
plt.xticks(rotation='horizontal')

total = float(len(NotChurnFirstSeg))
for p in ax.patches:
    percentage = '{:.1f}%'.format(100 * p.get_height()/total)
```

```
    x = p.get_x() + p.get_width() / 2 - 0.1
    y = p.get_y() + p.get_height()
    ax.annotate(percentage, (x, y), size=18)
```



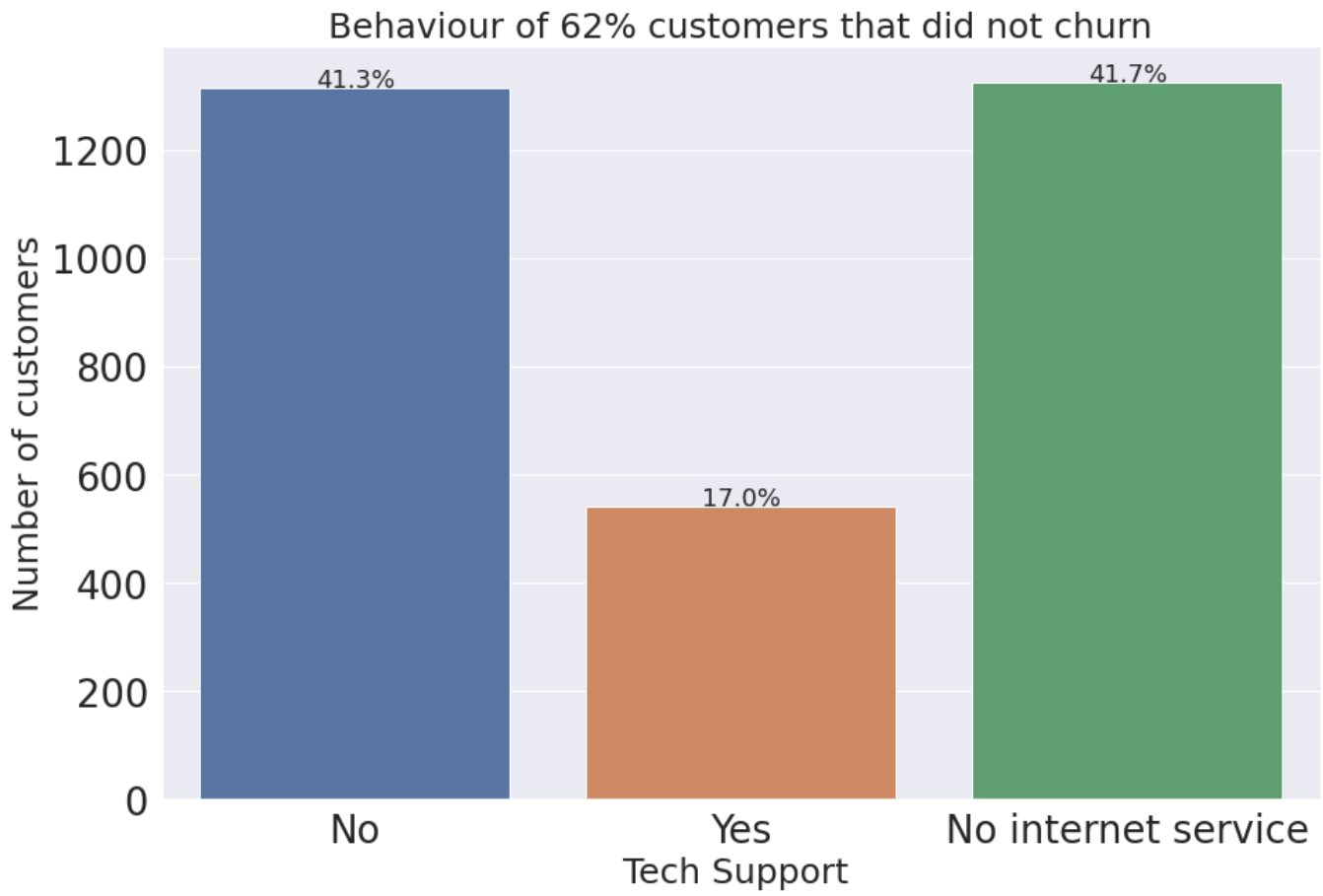

```
# Show behaviour of 62% customers that did not churn
plt.figure(figsize=(15,9))
ax=sns.countplot(x='Dependents', data=NotChurnFirstSeg)
sns.set(font_scale=2.5)
ax.set_title('Behaviour of 62% customers that did not churn' , fontsize = 25)
plt.xlabel('Dependents', fontsize=25)
plt.ylabel('Number of customers', fontsize=25)
plt.xticks(rotation='horizontal')

total = float(len(NotChurnFirstSeg))
for p in ax.patches:
```

```
    percentage = '{:.1f}%'.format(100 * p.get_height()/total)
    x = p.get_x() + p.get_width() / 2 - 0.1
    y = p.get_y() + p.get_height()
    ax.annotate(percentage, (x, y), size=18)
```



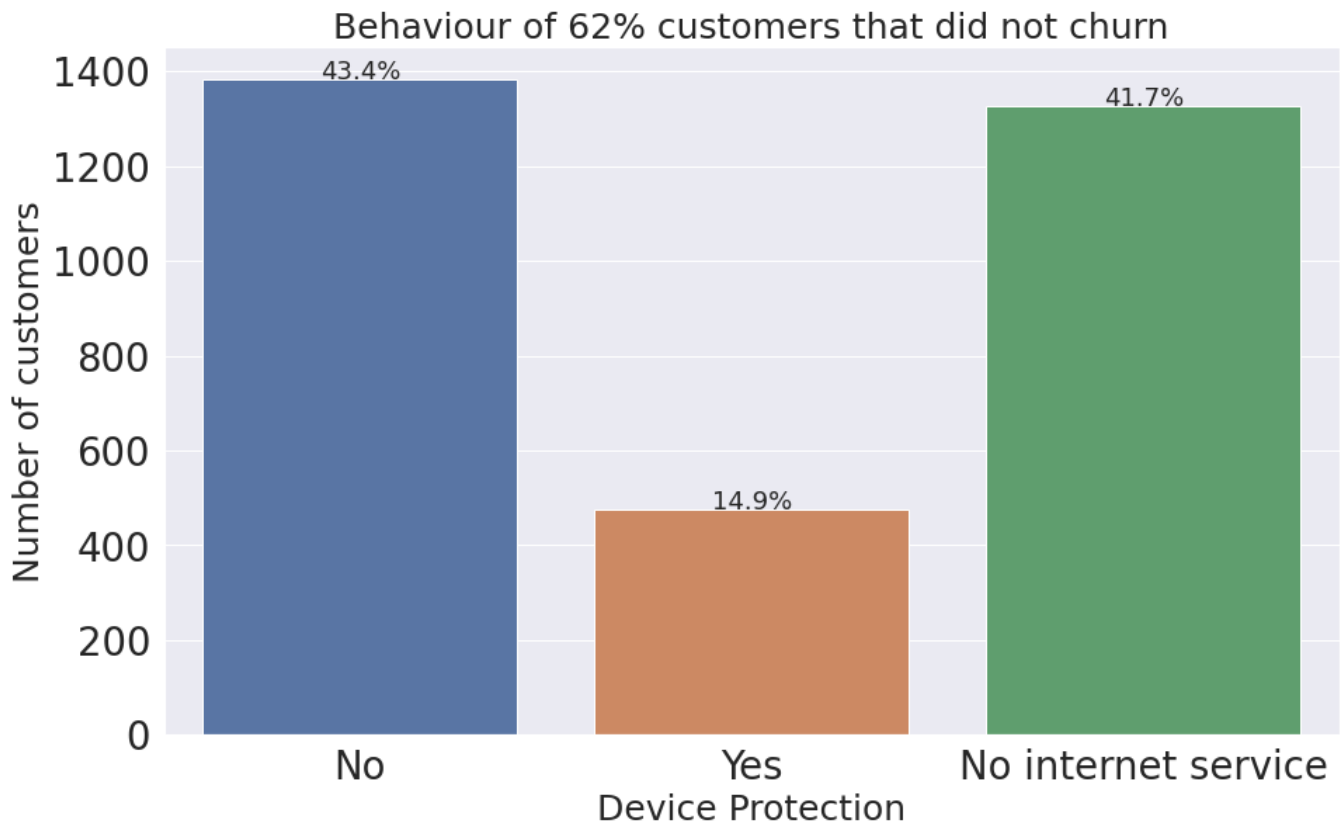

```
# Show behaviour of 62% customers that did not churn
plt.figure(figsize=(15,10))
ax=sns.countplot(x='TechSupport', data=NotChurnFirstSeg)
sns.set(font_scale=2.5)
ax.set_title('Behaviour of 62% customers that did not churn' , fontsize = 25)
plt.xlabel('Tech Support ', fontsize=25)
plt.ylabel('Number of customers', fontsize=25)
plt.xticks(rotation='horizontal')

total = float(len(NotChurnFirstSeg))
for p in ax.patches:
    percentage = '{:.1f}%'.format(100 * p.get_height()/total)
    x = p.get_x() + p.get_width() / 2 - 0.1
```

```
    y = p.get_y() + p.get_height()
    ax.annotate(percentage, (x, y), size=18)
```



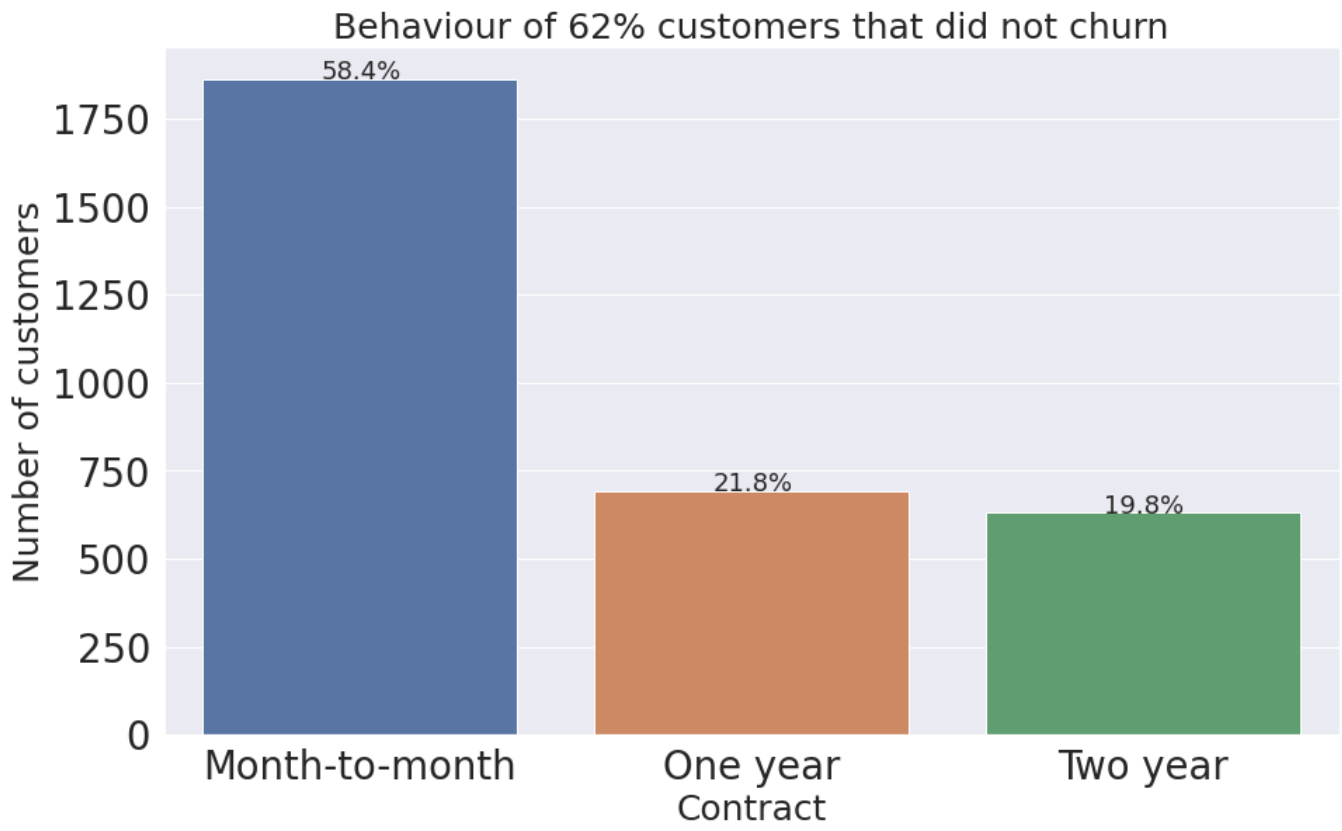

```
# Show behaviour of 62% customers that did not churn
plt.figure(figsize=(15,9))
ax=sns.countplot(x='DeviceProtection', data=NotChurnFirstSeg)
sns.set(font_scale=2.5)
ax.set_title('Behaviour of 62% customers that did not churn' , fontsize = 25)
plt.xlabel('Device Protection', fontsize=25)
plt.ylabel('Number of customers', fontsize=25)
plt.xticks(rotation='horizontal')

total = float(len(NotChurnFirstSeg))
for p in ax.patches:
    percentage = '{:.1f}%'.format(100 * p.get_height()/total)
```

```
    x = p.get_x() + p.get_width() / 2 - 0.1
    y = p.get_y() + p.get_height()
    ax.annotate(percentage, (x, y), size=18)
```

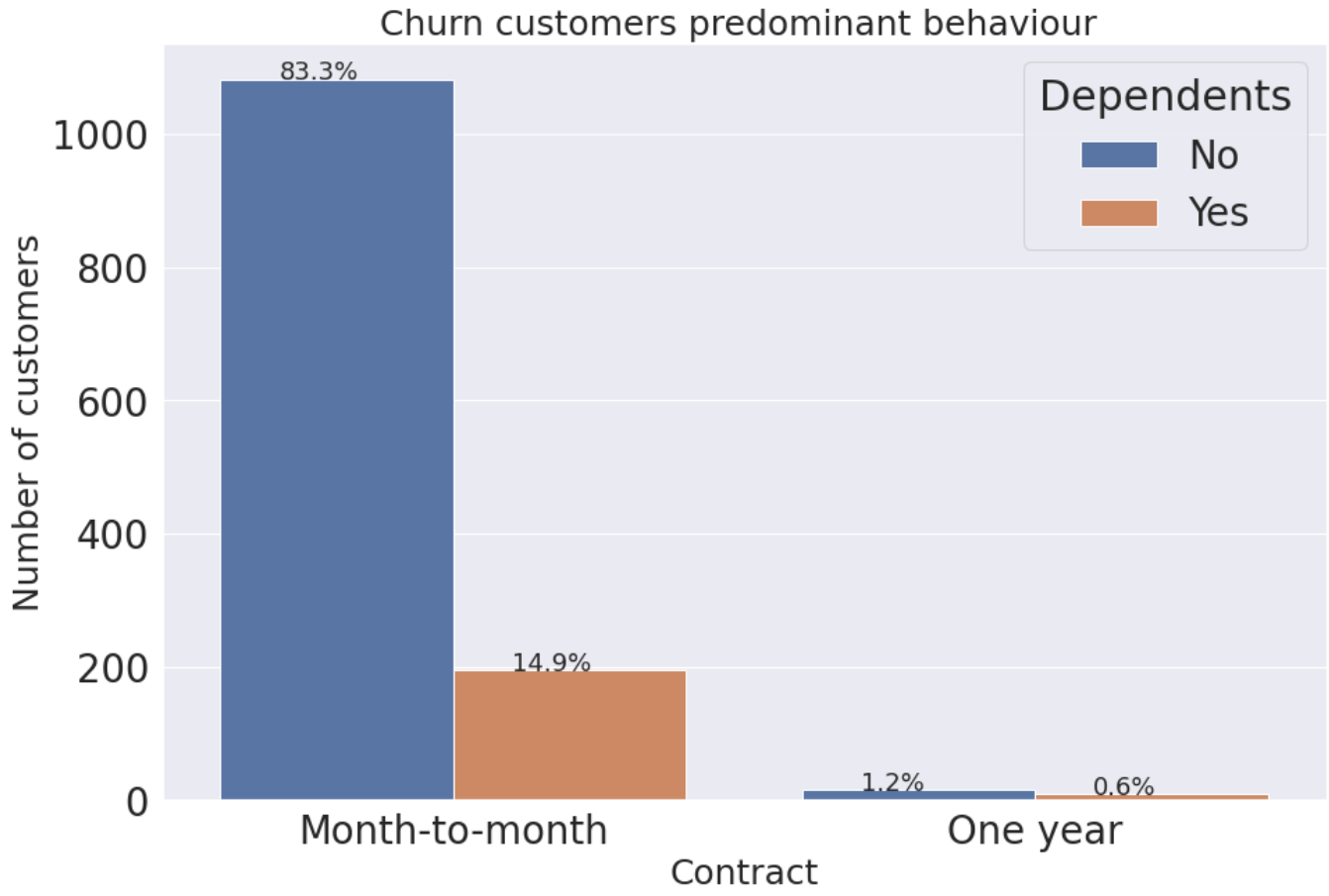



```
# Show behaviour of 62% customers that did not churn
plt.figure(figsize=(15,9))
ax=sns.countplot(x='Contract', data=NotChurnFirstSeg)
sns.set(font_scale=2.5)
ax.set_title('Behaviour of 62% customers that did not churn' , fontsize = 25)
plt.xlabel('Contract', fontsize=25)
plt.ylabel('Number of customers', fontsize=25)
plt.xticks(rotation='horizontal')

total = float(len(NotChurnFirstSeg))
for p in ax.patches:
    percentage = '{:.1f}%'.format(100 * p.get_height()/total)
    x = p.get_x() + p.get_width() / 2 - 0.1
```

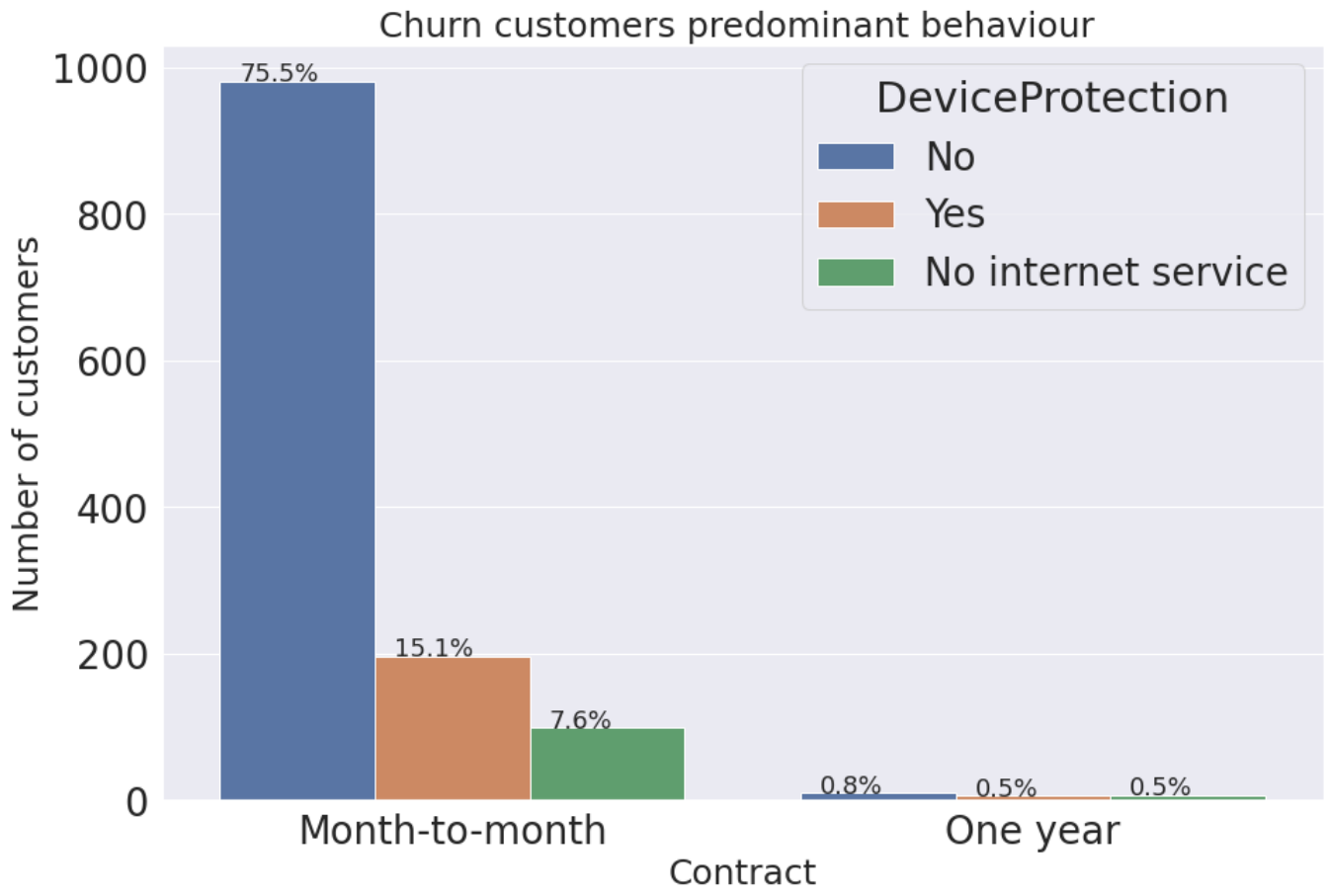
```
    y = p.get_y() + p.get_height()
    ax.annotate(percentage, (x, y), size=18)
```




```
plt.figure(figsize=(15,10))
ax=sns.countplot(x='Contract', hue="Dependents", data=FirstSegment)
sns.set(font_scale=2.5)
ax.set_title('Churn customers predominant behaviour ' , fontsize = 25)
plt.xlabel('Contract', fontsize=25)
plt.ylabel('Number of customers', fontsize=25)
plt.xticks(rotation='horizontal')

total = float(len(FirstSegment))
for p in ax.patches:
    percentage = '{:.1f}%'.format(100 * p.get_height()/total)
    x = p.get_x() + p.get_width() / 2 - 0.1
    y = p.get_y() + p.get_height()
    ax.annotate(percentage, (x, y), size=18)
```




```
plt.figure(figsize=(15,10))
ax=sns.countplot(x='Contract', hue="DeviceProtection", data=FirstSegment)
sns.set(font_scale=2.5)
ax.set_title('Churn customers predominant behaviour ' , fontsize = 25)
plt.xlabel('Contract', fontsize=25)
plt.ylabel('Number of customers', fontsize=25)
plt.xticks(rotation='horizontal')

total = float(len(FirstSegment))
for p in ax.patches:
    percentage = '{:.1f}%'.format(100 * p.get_height()/total)
    x = p.get_x() + p.get_width() / 2 - 0.1
    y = p.get_y() + p.get_height()
    ax.annotate(percentage, (x, y), size=18)
```


Churn customers predominant behaviour
DeviceProtection
No
Yes
No internet service
Number of customers
1000
800
600
400
200
0
75.5%
15.1%
7.6%
0.8%
0.5%
0.5%
Month-to-month
One year
Contract